ILLUMINATING ENGINEERING

APRIL 1954

•

Daylighting with New Toplighting Designs

New Twists to Conventional Systems

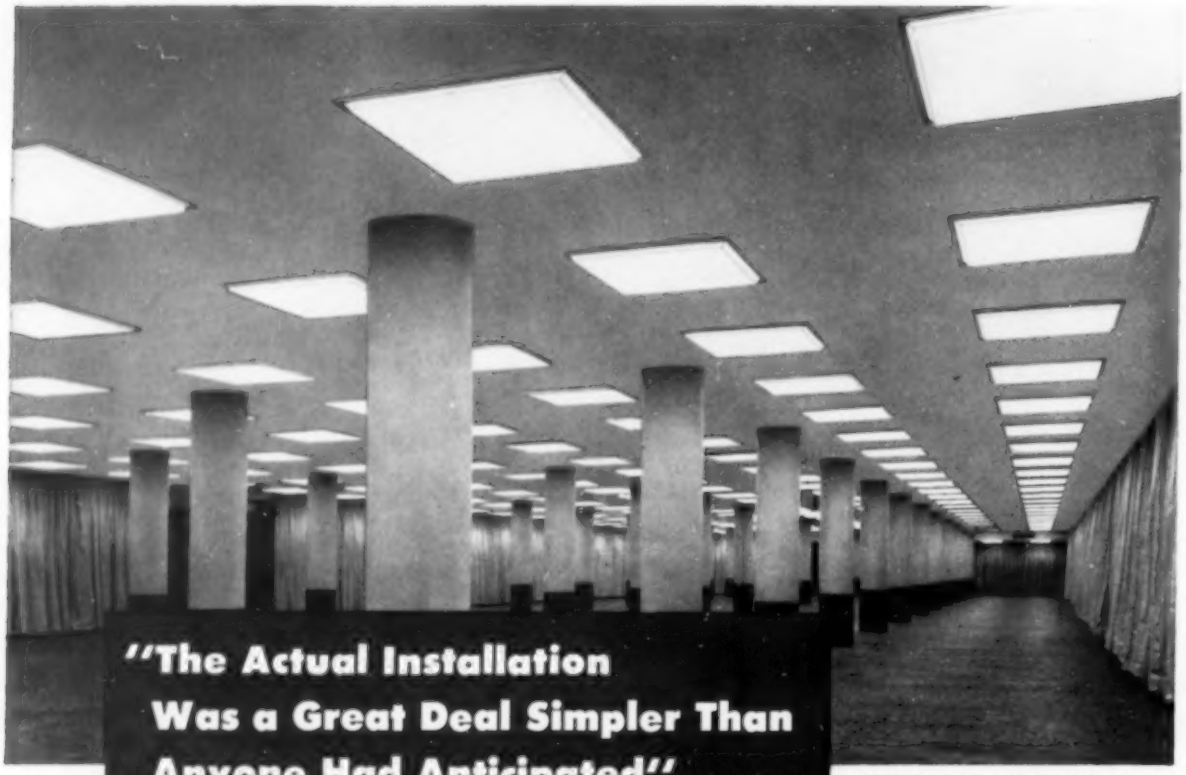
Modular Coordination in Lighting

More Interflectance Factors

School Lighting and Posture

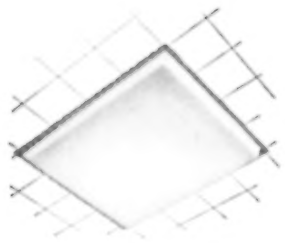
Committee Personnel

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY



"The Actual Installation Was a Great Deal Simpler Than Anyone Had Anticipated"

DISTRIBUTOR: Graybar Electric Co., Inc. Detroit, Michigan



INSTALLATION DATA

Area—22,400 Sq. Ft. Ceiling height—12'.

217—4' x 4' flush type Beta-Plex units each with 6 4500° cool white 40W-T12 lamps.

Beta-Plex Units wired for 3 levels of lighting.

Shortly after installation was completed tests were made and the results were as follows:

	6 lamps	4 lamps	2 lamps
Horizontal illumination	74 ft-c.	49 ft-c.	25 ft-c.
Vertical illumination	41 ft-c.	27 ft-c.	14 ft-c.

	Reflection Factor	Type of Material
Ceiling	85%	Metal acoustic
Walls	62%	Existing steel encasement windows
Dado	25%	
Floor	28%	Clean tile floor—tan buff color

So Says Brooker Electric Company, Inc., After Installing 217 Wakefield Beta-Plex Units in an Automobile Manufacturer's Display Room

"In undertaking this project we felt that installing and supporting a 4 ft. square fixture would present quite a problem due to the weight of the fixture. However, the actual installation was a great deal simpler than anyone had anticipated.

"The ceiling manufacturer increased the size of the fixture framing channel to carry the weight of the fixture. Wakefield designed the fixture supporting brackets so that they would rest on the framing channel. Consequently, when the fixtures were installed, additional supports for the fixtures that originally were anticipated were not required due to the precise job of engineering performed by the Wakefield Company.

"To the best of our knowledge this was the first installation of its type in this locality, and the Wakefield people are to be congratulated for their accomplishments."

(Signed) C. RAY DAVISSON, president
BROOKER ELECTRIC COMPANY, INC., DETROIT, MICHIGAN

For an illustrated, descriptive 8-page folder on Beta-Plex, write to The F. W. Wakefield Brass Company, Vermilion, Ohio. In Canada: Wakefield Lighting Limited, London, Ontario.

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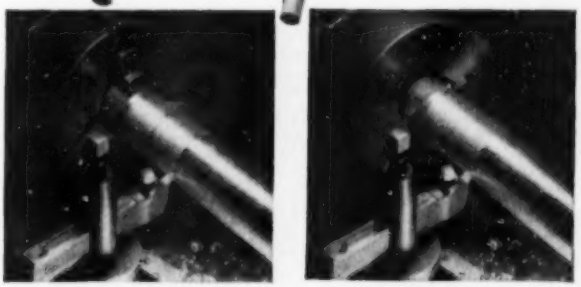

In left-hand photo, the lathe is purposely stopped to demonstrate the dangerous illusion that can result under conditions where series ballasts are in use. *In right-hand photo,* the lathe is in operation, an apparent fact when the light source incorporates a *lead-lag* ballast.

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on the Starring

140HPF

against Supplement 2 to Proposed
ASA Specification C82.1

ELECTRICAL TESTING LABORATORIES, INC.

TESTS OF FLUORESCENT LAMP BALLASTS

CTL Spec. No.	Size	Supply Voltage	Lamps to Reference Lamps						Ballast Loss at Rated Volts	Overall Power Factor	Base Shape	Voltage Across Starter Terminals	Dielectric Strength Test	Hot Res. Value	Time	Ambient Temp.	Heating Test					Insulation Temp.
			Voltage	Line Current	Power Factor	Line Current	Ratio Peak to Line Current	Percent Current														
Std	Amstr		103.0	0.445	46.0												Specimen No. 6-6-Normal					
"		213	107.0	0.346	34.0																	
"		236	114.0	0.413	42.8																	
"		240	102.0	0.476	44.4																	
6-6	Sta	118	178	285		0.382	37.0	0.550	1.49	0.598												
	Tot					0.410	48.0					11.0	99.3									
6-7	Sta		176	213		0.386	37.2	0.548	1.41	0.612							Standard Starter					
	Tot					0.444	48.0					10.8	98.4									
6-8	Sta	106	176				23.6															
	Sta	118				0.387	37.4	0.550	1.42	0.598												
	Tot					0.448	47.0					9.6	97.9									
	Sta	130		213			43.8															
6-9	Sta	106	176				23.6															
	Sta	118				0.384	37.6	0.545	1.48	0.608												
	Tot					0.418	48.0					10.8	97.6									
	Sta	130		213			44.8															
6-10	Sta	106	176				23.2															
	Sta	118				0.382	37.2	0.546	1.48	0.608												
	Tot					0.412	47.8					10.6	98.3									
	Sta	130		213			43.8															
Std	Amstr		103.0	0.445	46.4																	
"		213	107.0	0.346	34.0																	
"		236	114.0	0.413	39.8																	
"		240	101.0	0.478	44.0																	

Tech Rep'd. 91 — 3703 18.19
Mod. Temp. C — 33.3 24.6
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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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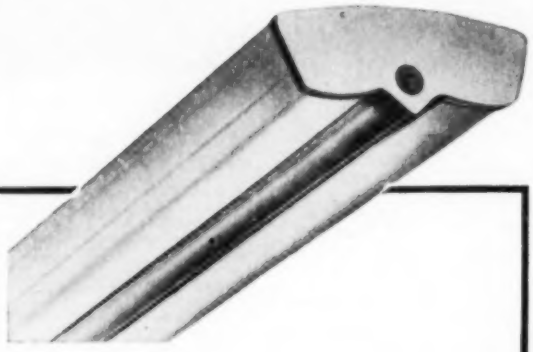

The new Curtis "Princess" luminous indirect luminaires have Curtis quality construction and workmanship throughout . . . with wire channel constructed of heavy gauge steel finished baked white "Fluracite" enamel. Side panels are fine ribbed durable polystyrene plastic to softly diffuse the light and provide low-brightness ratios between the ceiling and luminaire. Curtis "Princess" luminaires are available to accommodate all 4′, 5′ and 8′ fluorescent lamps. Send coupon for complete descriptive information.

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Let's Have Modular Coordination in Lighting

By T. D. WAKEFIELD

FOR MODULAR coordination of building materials in the building field, many industries have agreed upon the four-inch module. Doors are available in the four-inch module. So are electrical panels, wall board, ceramic products, some movable steel partitions, most window sash and many other building products. It is possible for the lighting industry also to give the architect and builder what they want in modular coordination of products. But very little lighting equipment is on the four-inch module.

A good architect integrates materials and products so that they work together as a whole, each enhancing the functional contributions of the other. Architects are generally agreed that modularity saves drafting time, hence gives more opportunity for consideration of better design. Manufacturers of modular products and their dealers have come to appreciate the manufacturing economics and the smaller inventories required. The building contractor appreciates the elimination of waste and the saving in construction time.

All these mean benefits to the consumer, though as yet he is not fully aware of them. Little convincing has been done consumer-wise, but by no stretch of imagination will there be resistance to the self-evident advantages of modularity. When the consumer says that he wants it modular, the lighting industry will face the high court of consumer opinion — where decisions are seldom reversed.

Information is beginning to reach consumer levels. It is significant that the A.I.A. and the Producers' Council have doubled their subscriptions to the modular coordination program for 1954. Such publications as "Economy by Modular Coordination" by William Demarest, Jr., of the A.I.A. are now available from the Government Printing Office. *Business Week* in August 1953, carried an article "Top Architects Seek More Mileage per Dollar by Using Materials That Fit a Common Modular Pattern." These indicate other handwriting on the wall.

The four-inch module grew from the Standardization program of the 1920's when the Commerce Department under ex-President Herbert Hoover helped establish regular sizes for tin cans. The idea was adopted by Albert F. Bemis, a Boston engineer. A working program for the building trade, based on a four-inch module, stemmed from his Bemis Foundation.

In 1938 the Producers' Council, Inc., and the American Institute of Architects jointly sponsored Committee A62 of the American Standards Association to study dimensional coordination. They were joined later by the National Association of Builders. The committee did much to publicize the four-inch module among manufacturers, many of whom have recast their products in modular measurements. The glass block industry was the first to adopt the modular principle.

When fluorescent lamps came along, with the best of intentions the makers acknowledged the soundness of modularity and cooperated by conforming to the four-inch module. Unfortunately that conformation to the Bemis convention brought grief to the lighting equipment manufacturers attempting to fall in line with the trend.

When a lamp on a four-inch module is included in a lighting unit, 48 inches becomes $48\frac{1}{16}$ inches to include the metal enclosure on both ends. And when the equipment is butted together in rows, the

Figure 1. Modularity attained by continuous runs of channels, with modular lamp and socket combinations butted tightly together.

AUTHOR: Vice-President, F. W. Wakefield Brass Co., Vermilion, Ohio; Member of the Joint Committee of the American Institute of Architects and the Producers' Council, Inc.

one-sixteenth inch can become an inch or more. Modularity is lost along with its inherent economies. A parallel would be the brick manufacturer who does not allow for the mortar.

Now let's look at the problem of the lighting equipment manufacturer in choosing lamp and socket combination dimensions:

Socket Type	Back to Back Dimension
Push Contact Bi-pin	$49\frac{3}{32}'' \pm \frac{1}{32}''$
Butt-on Bi-pin	$48\frac{1}{8}''$
Rapid Start Bi-pin	$49\frac{1}{8}'' \pm \frac{1}{32}''$
Slimline Socket	$48\frac{13}{32}'' \pm \frac{1}{16}''$

It is practical to make lighting equipment half-modular, in width only. But the length, when enclosed in the metal box as required for some types by the Underwriters' Laboratories, cannot conform with the width to achieve full modularity.

It can be attained in banks or continuous runs of channels when modular lamp and socket combinations butt tightly together. Such a system as is shown in Fig. 1 is approved by the Underwriters, and it meets the requirements of the American Standards Association, Committee A62, for coordination of dimensions of building materials and equipment.

But the lighting industry has yet to design and manufacture standard modular equipment as other industries are doing. The consumer wants economy. Modular coordination is in line with economy. No industry can afford to be out of step with a trend which will increase as more consumers accept the economies of the modular, as compared with the waste of the traditional cut-and-fit which is already archaic is some other industries related to building and modernization.

Luminous Soffit Lights a Classroom

The partial luminous ceiling in this classroom, at the Liverpool School in Liverpool, N. Y., provides illumination of about 40 footcandles. With a soffit depth of 10 inches, the partial ceiling is 24 feet long. Its width at the top is 11 feet 8 inches and at the bottom 10 feet. The slanting side curtain has a slope of 45 degrees. The vinyl plastic panels are mounted on the side away from the windows.

Architects: Sargent, Webster, Crenshaw and Folley; photo courtesy of Luminous Ceilings, Inc.

New Twists To Conventional Systems

Winners in last year's contest for Interesting Installations revealed unusual techniques for solving lighting problems. Four such winners are shown on the following four pages.

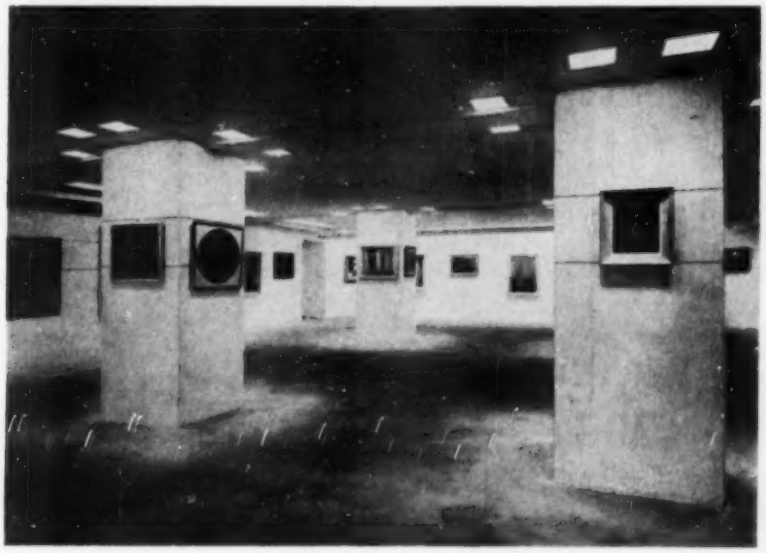
Parthenon Replica Plus Modern Lighting for Art Gallery

Tennessee Valley Section Entry by S. B. LeCornu

ONE of the most outstanding buildings in Nashville, Tennessee is the beautiful replica of the Greek Parthenon, built in the twenties to commemorate Tennessee's centennial of statehood. Recently this famous structure became the permanent home for local art treasures and a gallery for visiting exhibits. As the local permanent collection grew, and as more and more traveling exhibits were attracted to the gallery, additional space had to be developed by renovating an unexcavated area in the sub-basement. Mechanically, renovation was difficult as the ceiling height by structural necessity had to remain very low, and a maze of pipes and supports made it even lower. With the aid of modern materials undreamed of in the day of the ancient Greek Masters, however, a room was created which is a credit to the beautiful structure which houses it.

Lighting has always been a problem in buildings following pure Greek design. Even to this day no one knows how the statue of the Goddess Athena was illuminated, as no fenestration was incorporated into the original design of the Parthenon.

For the renovated basement area, a design



Purely functional in design, the illumination is sufficient on the points of reference, with adequate brightness in the traffic areas.

planned by S. B. LeCornu, Lighting Engineer with the Nashville Electric Service Board, included perimeter lighting of the walls with recessed fluorescent units using two 40-watt standard warm white lamps behind directional control lenses. Each luminaire directs maximum candlepower at 15 degrees with the vertical, which is the optimum for highest illumination values commensurate with a minimum of specular reflection. Due to interference of pipes in the ceiling, some of the units had to compromise with the ideal angle. The beam spread through the section is narrowed to 25 degrees to give a high intensity, and in the lateral plane along the wall the light curve is spread out to 90 degrees to create an overlap for the reduction of shadows. Four large columns are spaced in the room, each with four faces of sufficient size to permit the display of a painting. Due to structural interference it was impossible to follow the use of fluorescent recessed units, and incandescent units were used with a similar light pattern in these areas. The resulting illumination on these columns creates the illusion of illuminated pylons. No other lighting is needed for general room illumination. The lighting is purely functional in design, yet is sufficient on the points of reference with adequate brightness in the traffic areas. The color quality of the standard warm white fluorescent lamps blends well with the incandescent, for a good color rendition in viewing the paintings. In summary, the overall ceiling pattern is clean and classical, reflecting a functional design.

Eglise St. Vincent de Paul

Quebec Chapter Entry by Romeo Martineau

TO REPLACE its beautiful predecessor, burned out a few years ago, this Roman Catholic Church in Quebec City, Canada, was built on a restricted budget for all items, including the lighting. Ceiling is painted dark brown with white trim, walls are white plaster, benches walnut finish. All lighting in the assembly area is from mirror reflectors concealed in the ceiling elements, using variously 500-watt, 750-watt and 1000-watt lamps. For even distribution of illumination over the area, asymmetric reflectors are used in the curved ceiling, obtaining straight down lighting.

Levels of 15 to 17 footcandles, with minimum glare, are obtained over the pews. In the altar area, three such units are supplemented by the additional installation of two 300-watt projector spotlights on

Eglise St. Vincent de Paul, with all lights on.

each side concealed behind the balcony pillars, and aimed at the altar. The illumination level in the entire altar area is of the order of 18 to 20 footcandles.

A statue of St. Vincent de Paul, recessed in a niche above the altar stands out in relief against a white background, and is illuminated with concealed 15 mm white cold cathode tubing.

The entire lighting plan was conceived by Romeo Martineau, of La Cie Martineau Electrique Limitee, Quebec, and the installation carried out under his direction, with the cooperation of the architect.

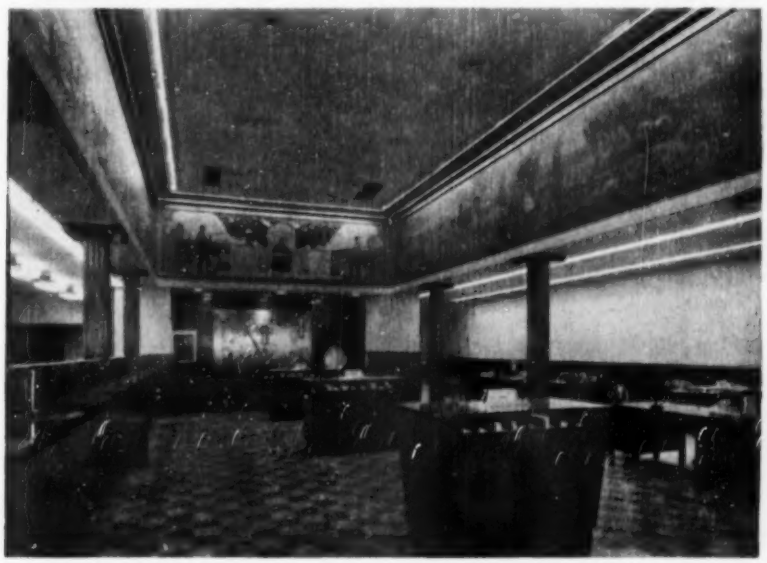
Rearranging Architectural Elements For Lighting a Mural

Iowa Section Entry by J. C. Young, Jr.

RELIGHTING for unusual architectural elements is ever a challenge. In the case of the bank lobby shown, a mural on all sides offered an especially interesting lighting problem. Its solution won for J. C. Young, Jr., Iowa Electric Light and Power Company, Cedar Rapids, first prize in the 1953 contest for "My Most Interesting Lighting Job" conducted by the Iowa Section of I.E.S.

The area is the lobby of the Peoples Bank and Trust Company, Cedar Rapids. In the "before" job, the ceiling was 23 feet high with windows above the mural, which extended all sides of the room. While this architectural arrangement provided light for the mural, it also created a higher brightness so distracting one scarcely noticed the wall.

In the relighting plan, a new ceiling was suspended immediately above the mural and below the windows, to a new ceiling height of 16 feet. Effective illumination for the mural was accomplished by recessing two 37-foot 6-inch and two 18-foot specular aluminum paracyl reflectors with a 16-degree beam angle, in a continuous strip completely around the room. These units are located nine inches in from the ledge above the mural and use cool white de luxe lamps for better color rendition of the painting. Vertical footcandles on the mural range from 35 at the top to 12 at the bottom.



Mural, which is 5 feet 2 inches high, is lighted by continuous strip; general lighting in lobby is from eight recessed downlights.

General lighting for the lobby is from eight downlights recessed into the new ceiling. These are on nine-foot spacings and use 500-watt PS-40 inside frosted lamps. An average of 25 footcandles is obtained on the customers check desks in the center of the lobby, 42 inches above the floor. Fluorescent units over the tellers' cages and account desks predated the remodelling project.

Luminous Glass Ceiling in a Canadian Home

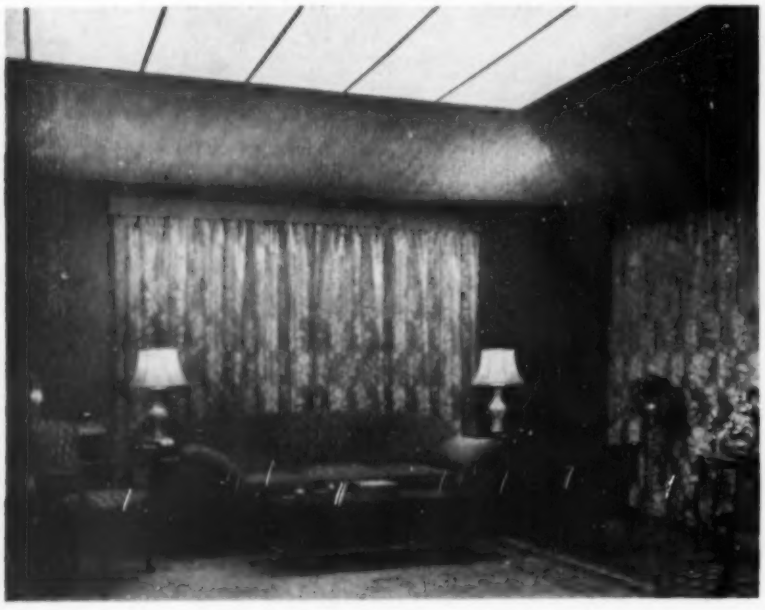
British Columbia Section Entry by H. H. Arnold

AN INTERESTING departure from conventional residence lighting techniques was a feature of the installation which won first prize in British Columbia Section's 1953 contest. The design is by H. H. Arnold, a consulting engineer for lighting, West Vancouver, B. C.

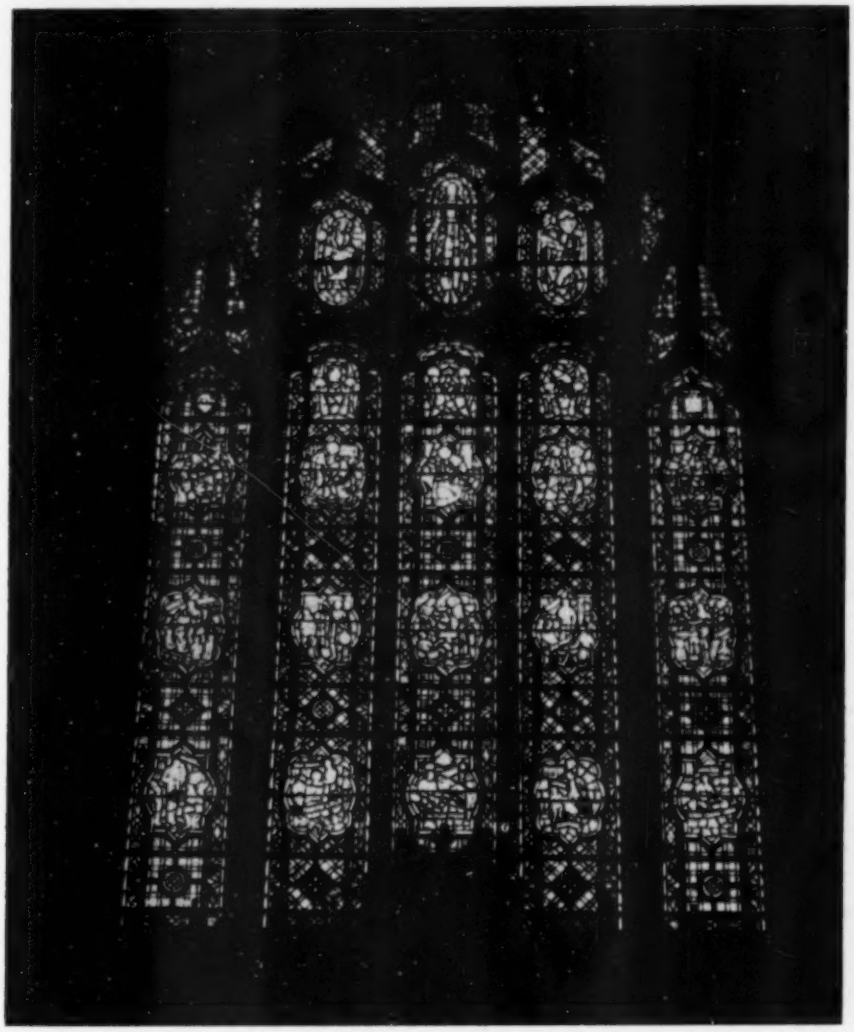
In a living room 16 feet by 22 feet, a luminous ceiling has been created in the centered "skylight," nine feet three inches above the floor. Fluorescent T12 48 lamps spaced horizontally on 12-inch centers are mounted on the recessed portion of the room's ceiling, with the axis of the lamps nine inches above the sections of pentacore glass. About three-quarters of an inch below this serrated pentacore glass are two-foot by six-foot sections of light amber cathedral glass. Surface brightness of the panel is about 225 footlamberts.

The remainder of the ceiling, which is paneled with light-finish Canadian oak, has a reflectance of 70 per cent; walls, also of oak range between 65 and 75 reflectance. Draperies are in relatively light tones of mushroom.

Readings were taken after 16 months of operation, during which period there was no cleaning of panel glass or panel lighting. At the table height under the center of the panel, illumination levels were 40 footcandles. On the sofa at the edge of the panel, illumination levels were 30 footcandles, which increased to 50 footcandles when the supplementary lamps were turned on.



At the sofa, illumination level is 30 footcandles, which is increased to 50 footcandles when table lamps are also turned on.



INSTALLATION AT THIRD PRESBYTERIAN CHURCH, ROCHESTER NEW YORK.

Lighting a Stained-Glass Window

LIGHTING OBJECTIVE: To illuminate a church stained glass window which receives no daylight because of an adjacent structure.

GENERAL INFORMATION: When this 60-year-old church was remodeled the sanctuary was enlarged and a stained glass window installed over the communion table. Because this window receives no daylight (the parish building is directly adjacent to the church) an electric lighting system was essential. The church is about 100 feet long.

INSTALLATION: Twenty-three 25mm 3500K white cold cathode fluorescent lamps operating at 60 ma are spaced on 8-inch centers as shown in Figure 2. The top lamp overlaps the top of the window by a few inches and the bottom lamp is about even with the bottom of the window. The

(over)

A.I.A. File No. 31

enclosed space behind the window is 18 inches deep. The lamps are mounted close to the metal reflecting surface which was spray painted flat white. Openings were provided top and bottom for ventilation, and doors at both ends for servicing.

Provision was made for future installation of lamps on 4-inch centers but this increased illumination was not found necessary. The equipment operates through an auto transformer dimmer which provides a dramatic effect when the lighting is turned on or adjusted.

One difficulty was encountered at the outset due to differences in the transmittance of the glass. Parts of some of the medallions were quite light and permitted the horizontal lines of the lamps to show through. This was corrected by painting a narrow line along the fronts of the lamps involved. The brightness of the glass varies from 6.6 footlamberts (light shirt on center figure in bottom row) to the 1.2-footlambert purple throughout the entire window area. The details of the window are visible from about 40 feet.

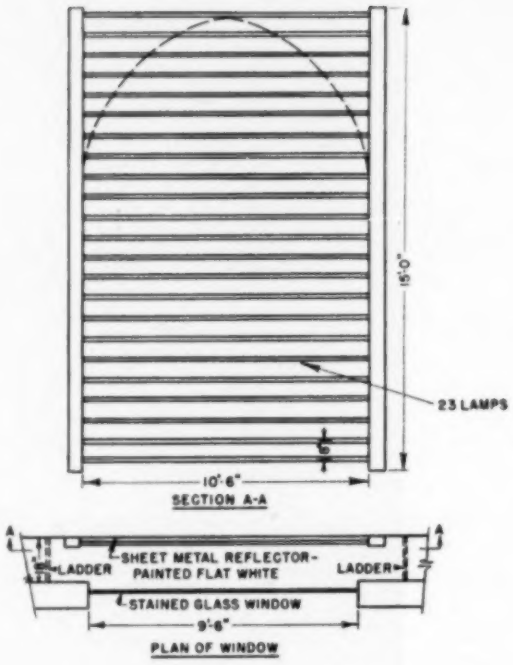


Figure 2.

Architect: Waasdorp and Northrup; consulting engineer: Realto E. Cherne; lighting contractor: Empire Neon Lights, Inc.; technical consultant: Herbert Trotter, Jr.

Lighting data submitted by Realto E. Cherne, 311 Alexander Street, Rochester, New York as one solution to a lighting problem and to aid in the design of similar installations.

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Functional Top Lighting With Glass Block

By H. F. KINGSBURY
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THE PRINCIPLES of optical control and thermal insulation found in functional glass block, as we know them today, provide an avenue to improved skylight design. They lead to a solution of the problems of glare, condensation and temperature control. It is the purpose of this paper to present the basic illumination data on a new skylight design based on these principles and to show how it can be combined with electric lighting in low ceilinged spaces.

Skylights in one form or another have been used by man almost since the birth of enclosed structures. Perhaps the first "functional top light" was the smoke hole used by primitive man to let smoke out and light in. Later in history, many of the public buildings of Greece and Rome were lighted by openings from above. In more modern history the horticulturists of the early 18th century appreciated the value of skylight as a source of natural daylight for their plant life. The first early use of the glazed skylight appeared in conservatories. The expense of such projects was great and the use of the skylight was limited. Our architecture at that time was designed for a less luxurious way of life, and no parallel was found in such work on the American scene.

The 1800's gave birth to the most significant developments in the use of the skylight. Probably the most outstanding and spectacular building of that time was the fabulous Crystal Palace designed by Sir Joseph Paxton for the Great Exposition of 1851. Throughout this period iron and glass buildings achieved great popularity in conservatories, railway stations, arcades and galleries. The basis for present day metal-glass rooflights was established. The 1890's and the early 20th century saw the interest of leading European designers turn to concrete-glass skylights with heavy prism glass. The Keppler System established the basis for this type of construction.[1] The Kodak Building of 1910 was one of the first uses of this glass-concrete skylight.[2] These beginnings, fostered by their appreciation of toplighting, made European designers the leaders in this type of design.

The development of the skylight throughout the 19th century met with many practical problems. Designers offered solutions which were never completely satisfactory. However, even then these men visualized[3] how some of the building materials of today could overcome such problems as condensation, glare, and temperature control which plagued them in all their skylight design.

Concrete-glass construction has been used in America in a restricted manner. Most familiar are sidewalk lights. Some use also has been made of a concrete-glass rooflight. However, cost, maintenance, and poor control of glare, condensation and heat gain have restricted its application.

Glass blocks form an excellent medium for the admission of daylight through toplighting panels as well as through side walls. For example, laid up in horizontal reinforced concrete panels they resist the elements and the loads typical of roof usage. They provide more than twice the resistance to heat transmission provided by single glazed sky lights, and because of their durable enclosed optical surfaces, they can be designed for brightness control with the assurance that the distribution characteristics will not be greatly changed by dirt collection or changes in structure. Many European installations of glass block-concrete panels have served satisfactorily for a number of years.

One of the design principles of importance insofar as strength and durability of the skylight slab are concerned is the relation of concrete joint width to glass area. It also offers an interesting measure of design flexibility to the lighting engineer in that the average light transmittance of a slab can be varied by adjusting the width of the concrete joint. With 12-inch glass block around which the new system is designed, the joint width can be anywhere from the minimum 2¼ inches, to any practical maximum that may be desired. Such design freedom allows the architect or lighting engineer to predetermine the glass area required and then plan the toplighting panels and layout on the basis of light distribution, aesthetics, or required building dimensions.

Early in the design program it became desirable

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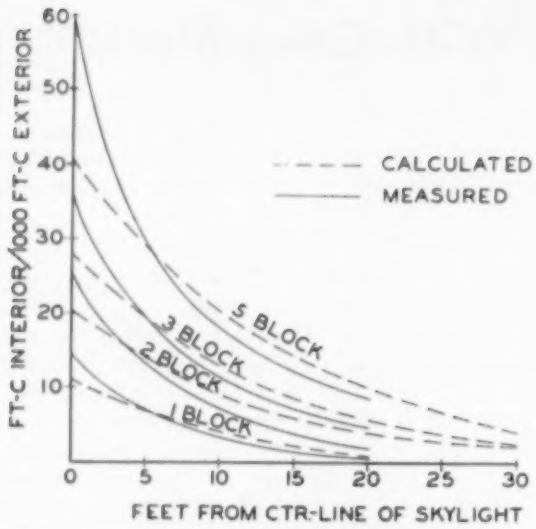

Figure 1. Comparison of calculated and measured illumination distributions for skylights of various block widths (1, 2, 3, and 5) in a room 20 feet square with 10-foot ceiling height.

to calculate and predict illumination and brightness levels that might be obtained from various sizes of skylights under various exterior conditions. In making such calculations in the early stages of the program, the only data available was the probable light transmittance of the glass block. Assuming then that the concrete joint between the blocks would be black, the average brightness of a skylight panel per unit of exterior illumination was determined. These data in combination with known ceiling height and distance relationships were used to calculate illumination distributions perpendicular to the length of the skylight by application of the cosine law and the data contained in the *I.E.S. Lighting Handbook*.[4] It was also desirable to calculate the general room brightness relationships for such skylights, using the interflectance tables.[5] For the condition of a complete "luminous" ceiling calculated values and data obtained later by direct measurement are compared in Table I.

A test room 20 feet square was constructed and completely toplighted using the new block design and 3¼-inch concrete joints. The concrete was white on the underside. The room was decorated with high reflectance surfaces and by masking out various portions of the skylight with high reflectance ceiling panels the calculated illumination distributions were checked by actual measurement under various exterior conditions. The comparison between these measured distributions and the calculated ones which assumed a perfectly diffusing source of uniform brightness is shown in Fig. 1. The measurements were made using the photo recorder described in a previous paper,[6] so that data for a wide range of exterior conditions including both overcast and sunny days could be easily included for the purpose of comparison of these conditions.

The departure of the measured data from the calculated values is partially caused by the slab joints which perform as louvers, partly by the

TABLE I.—Comparison of Calculated and Measured Brightness Distributions in a Room 20 Feet Square and with a 10-Foot Ceiling. Calculations by Use of Interflectance Tables.

Average Brightness of Panel for 1000 ft-L Sky Brightness — 240 ft-L Reflectance of Walls — 53% Reflectance of Floor — 26%	Calculated	Measured
Average Illumination	240 ft-c[1]	105 ft-c[2]
Average Wall Brightness	52.4 ft-L	48 ft-L
Average Floor Brightness	60.7 ft-L	35 ft-L

[1]For very large room with length and width infinite as compared with height.
[2]In small room.

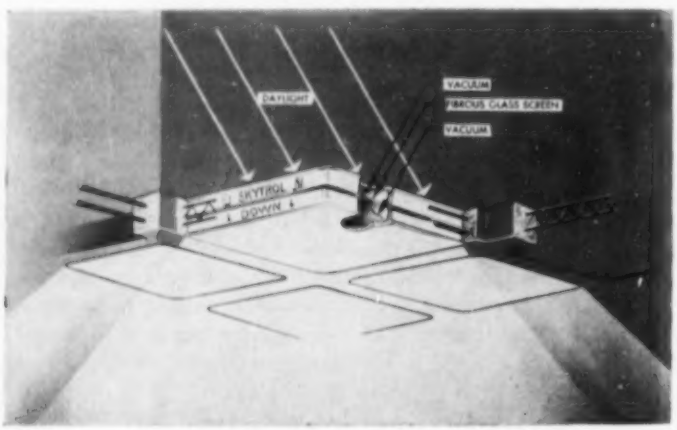

Figure 2. Essential design features of the new toplighting glass block and structure.

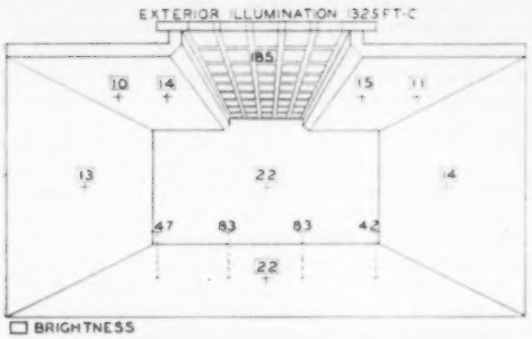

Figure 3. Brightness and illumination distribution in a room 20 feet square with 10-foot ceiling height toplighted with a panel of 12-inch glass block, 5 blocks wide and 15 blocks long.

louver effect of the "shaft" and partly by the somewhat asymmetric distribution characteristic of the glass blocks.

As finally developed, the block design consists of etched interior surfaces, a fibrous glass screen between the halves, and a cylindrical lens surface on the interior face. The top exterior face is smooth for easy construction and maintenance cleanability. See Fig. 2.

With a panel five blocks wide and fifteen blocks long the illumination and brightness distributions in a room 20 feet square with this skylight located above the center of the room and 11 feet above the floor are shown in Fig. 3. With such lighting distribution it becomes possible to adequately daylight interior office or classroom spaces without any dependence being placed upon vertical wall sections for such lighting.

To assist the lighting engineer in planning proper top lighting panels some "rules of thumb" have been developed. For example, for corridors up to a maximum width of about 10 feet a skylight composed of blocks spaced every 2 feet will give adequate corridor daylighting under a wide range of exterior conditions.

For complete top lighting of enclosed spaces, it has been established that the number of glass block required, for most conditions, is approximately equal to the floor area in sq. ft. divided by 6. This figure applies for most critical seeing areas, such as classrooms, offices, libraries, etc.

For service areas such as corridors, storage areas and rest rooms or where the panels furnish a secondary source of light such as in deep classrooms the number of glass block should be approximately equal to the floor area in sq. ft. divided by 12.

Where several skylight panels are to be used to daylight an enclosed space these panels should be located approximately on centers equal to the *ceiling height* for uniform illumination distribution, a

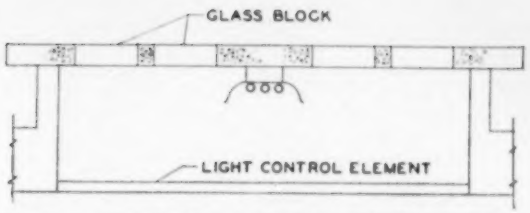

Figure 4. "Combination troffer" incorporating both daylight and electric lighting sources.

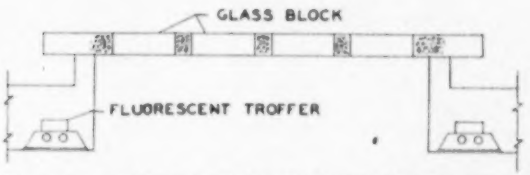

Figure 5. Combined daylight and electric lighting sources in another arrangement.

rule of thumb quite familiar to most lighting engineers. For maximum daylight utilization, it is suggested that the "shafts" between the skylight panel and true ceiling line be kept as shallow as possible and that the shaft walls be maintained at high reflectance, preferably above 80 per cent. As with all good lighting, the reflectance of the floors, desks or other furniture should be kept high, preferably above 30 per cent. To minimize brightness contrasts between the glass block and the concrete joint, and as an aid in raising illumination levels when the concrete web is large in area compared with the glass, it should be maintained at 80 per cent or higher reflectance.

There are several ways in which this new skylight design can be combined with electric lighting to form a "combination troffer." For example, it offers interesting possibilities for either luminous or louverall type ceiling installations. Fig. 4 shows such a possible combination. It can also be combined with fluorescent luminaires surrounding the skylight structure. Such a combination is shown in Fig. 5.

The assistance and guidance of Dr. A. H. Baker in the successful completion of this project is gratefully acknowledged, as is the work of Mr. V. U. Bizzaro in the tedious task of developing usable data from the illumination and brightness readings taken.

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2. Ibid., p. 182.
3. Ibid., p. 170.
4. *I.E.S. Lighting Handbook*, Second Edition, p. 9-26. The Illuminating Engineering Society, New York, N. Y., 1952.
5. Ibid., pp. 9-34, 9-37.
6. Billhartz, W. H., Kingsbury, H. F., McKinley, R. W.: "A New Daylighting Survey Technique Utilizing a Photographic Recorder and Physical Brightness Meters," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 1, p. 6 (January 1953).

DISCUSSION

J. W. GRIFFITH*: The authors state that many European installations of glass block concrete panels have served satisfactorily for a number of years. Do the authors mean that the installations have produced satisfactory daylighting conditions for a number of years? If this is their meaning, it would be more conclusive if they would show the test data upon which they base their conclusions.

Do the authors have any information on approximate costs for replacing a broken block when it it laid up in horizontal reinforced concrete panels?

What method do the authors recommend for reducing the heat load due to absorption in the glass block toplighting panel?

The authors state that for most critical seeing areas such as classroom, offices and library, the floor area in square feet divided by 6 will give you the number of glass blocks required for complete toplighting of enclosed spaces. If you take ¼ of the average illumination measured in Table I, you still do not have the recommended minimum of 30 footcandles for classrooms. This measured value is apparently for a room with the entire ceiling toplighted using the glass block design. It is further assumed that this is for a clean toplight with no dirt collection or snow reducing the transmission. Since this measured value is for the average illumination, it is assumed that the minimum value of the work plane would be considerably less than the measured value. It is rather difficult to see how the ⅙ of the floor area in square feet rule will produce adequate daylighting.

The authors do not state the wall reflectance of the room shown in Fig. 3. Assuming that the room was decorated with high-reflectance surfaces, the readings on the side walls are rather perturbing in Fig. 3. If a low-reflectance chalk board were placed on these side walls, the brightness ratio between the chalk board and a task such as white paper on a desk top would appear to be very low. Since the authors state that with such lighting distribution it becomes possible to adequately daylight interior offices or classroom spaces without any dependence being placed upon vertical wall sections for such lighting, it would be interesting to see a brightness ratio study of such a room with dark chalk boards on the walls.

E. W. CONOVER**: On reading over this paper we are of the opinion that it would have been greatly improved by eliminating that portion taken up in giving an historical sketch of skylighting and utilizing the space to elaborate more of the technical matter. The sketchy nature of these data makes it necessary to ask several questions, centering mostly around Fig. 3.

This illustration gives an exterior illumination of 1325 footcandles. Was this a test condition found on an overcast day? Here the panel brightness is given as 185. How is this reconciled with the statement in Table I that the average panel brightness for 1000-footlambert brightness is 240? What is the spacing of the points across the room width for those readings of illumination?

If we reduce these footcandle readings to the condition of 1000-footcandle exterior illumination we get 35, 63, 63 and 32. The high points appear to be below the edge of the glass block panel or about two and a half feet from the center.

Referring to the solid line curve for five-block wide skylight in Fig. 1 we read about 40 footcandles for this point instead of 63 and at 7½ feet from the center line, which we assume is about the position for the other two illumination points, we get about 22 footcandles. Fig. 2 is described as test results for the 20 x 20 foot room pictured in Fig. 3. Why don't the values check?

H. B. VINCENT*: Workers in the field have not been too prolific in the introduction of new materials for use in daylighting building interiors. The authors are to be congratulated on the introduction of a new functional fenestration medium which, it appears certain, will find many uses in improved utilization of daylight.

It is noted that the authors present no data concerning brightness under exposure to sunlight. While, in general, a diffusing medium of the type presented might be expected to have a lower maximum brightness than would occur with a non-diffusing fenestration, comparative information would be valuable.

The calculated average illumination presented in Table I appears difficult to interpret. The assumption of uniform brightness would seem to be at variance with the indications of Fig. 3.

DOMINA EBERLE SPENCER**: The paper contains some interesting applications of the interflection method to daylighting. It is certainly encouraging to see that workers in this field are making use of theoretical methods and are specifying both the light incident and the helios.

However, the details of the paper raise a number of questions. In the first place, the authors have not given sufficient basic data on the glass block to permit a calculation by the interflection method. Neither the transmittance nor the equivalent reflectance of the glass block is given. And in Table I, the authors compare calculated values for a very large room ($k_r = 0$) with measured values for a small room ($k_r = 0.5$). It is hard to understand why the authors chose to compare the incomparable!

If the calculated values in Table I are replaced by new values which apply to the room in which measurements were made, much better results are obtained. This can, of course, be done only by assuming values where necessary. The authors do not distinguish between the helios H_2 of the glass block with interflections and the helios H_{02} without interflections. The theoretical difference is 11 per cent. The authors do not give any information on the equivalent reflectance of their glass block ceiling. If we assume that the value of 240 ft-L in the helios H_2 (with interflections included) and that the equivalent reflectance of the ceilings 0.50, we have the following calculations:

$$k_r = 0.50, \quad \rho_1 = 0.50, \quad \rho_2 = 0.50, \quad \rho_3 = 0.30$$

	Calculated	Measured
Average Illumination	142 lumen ft^{-2}	105 lumen ft^{-2}
Helios of walls	52.0 ft-L	48 ft-L
Helios of floor	35.9	35

The agreement for wall and floor helios is astonishingly good — much better than the agreement implied in the paper by the meaningless comparison with calculations for an infinite room. The discrepancy of 26 per cent between measured and calculated values of illumination should perhaps be investigated. At first, one thinks of cosine error in the photocells, but this has apparently been corrected adequately as described in Reference 6.

Figure 1 is also of interest. Directly below the skylight, the calculated values are low. This fact suggests that the

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**University of Connecticut, Storrs, Conn.

glass block is considerably more directional than the perfectly diffusing surface assumed in the calculations. If the authors wish to apply the interflection method without assuming their glass block is perfectly diffusing, they should make measurements with a rectangular coordinate photometer such as that developed by John Losh.[1] With pharos ratios which apply to the type of glass block being used, and with measurements of the equivalent reflectance of the block, really significant toplighting calculations could be made.

If glass blocks are used in the ceiling, they must certainly be combined with some means of artificial lighting. Figures 4 and 5 show suggested procedures. Unfortunately both are unsatisfactory. The luminous output of the lamps is inefficiently employed; the resulting luminous environment exhibits high helios ratios and, therefore, does not give a good environment for seeing. If daylight enthusiasts want to *increase* the use of expensive ceiling constructions to permit the entrance of "free" light from the sky, they should provide luminous environments that are comparable in quality with the best artificial lighting systems. Perhaps this can be done, but the present paper has certainly failed to demonstrate the possibility.

1. John A. Losh: "A Rectangular Coordinate Photometer for Large Area Luminaires," I.E.S. National Technical Conference, Paper No. 24, 1953 (to be published).

H. F. KINGSBURY, W. H. BILLHARTZ and R. W. MCKINLEY*: We wish to thank the various discussors for their contributions by which means certain ambiguities and misunderstandings can be cleared up and pertinent questions answered.

The statement that many European installations have served satisfactorily for a number of years implied satisfaction from both the structural and daylighting viewpoint. While it is true we have no test data on these installations, we do have subjective observations by those intimately concerned.

Based on our experience of purposely breaking out and replacing glass-block in these skylights, we do not feel that it is an expensive field operation. Moreover, because of their position on the roof vandalism breakage should be quite limited and there is no reason to expect structural breakage. Assuming that Plant Maintenance personnel would handle the replacement, the cost is estimated at about $10.00 per block, on a single replacement basis, less if multiple replacement is required.

With respect to heat gain through such skylights, it can be readily demonstrated by reference to data published by the American Society of Heating and Ventilating Engineers that the instantaneous radiant gain through double-cavity glass block is significantly less than for other light admitting materials. Whether the heat build-up in the panel itself is a problem or not is largely determined by the adequacy of ventilation in the space below the skylight.

*Authors.

Mr. Griffith questions the "rule of thumb" of dividing the floor area by 6 to obtain the number of *glass block* required for complete top lighting of enclosed spaces. Since the floor area of the room in question is 400 sq. ft., the indicated number of glass block would be 67. The actual number of glass block in the skylight is 125 (15 each way plus concrete joints). 105 divided by 67/125 is 56 ft-c, well above currently recommended minimums.

Dark, low-reflectance chalkboards often require supplementary illumination to bring their brightness in balance with the rest of the room. This would be the case if such a board were included in the room shown in Figure 3. The reflectances of the surfaces in this room are walls — 53%, ceiling — 72% and floor — 26%.

In response to Mr. Conover's question the data shown in this figure are for experimental conditions, with the sky completely overcast. The panel brightness figure noted is for the seated observer and would be expected to be found in the normal field of view. In Table I, on the other hand, the brightness datum is for head-on viewing, taken for the purposes of calculations shown.

Dr. Vincent questions the apparent absence of brightness data for sun exposure conditions. We have not found any variation between the brightness under non-sun and sun conditions when both brightnesses are related to the same base of incident illumination, that of 1000 footcandles on the plane of the skylight.

The illumination positions shown in Fig. 3 are 2 feet and 6 feet from the center line of the room. At these distances, reference to Fig. 1 will show values of about 45 ft-c and 29 ft-c. Since Fig. 1 is the average of a large number of readings, taken under a variety of exterior conditions, dirt accumulations and wall reflectances, the difference observed is not surprising. The data of Fig. 1 were purposely selected to be conservative.

Dr. Spencer's comments on our interflection calculations are appreciated. Our only reason for choosing the very large room comparison was to illustrate the diffusing nature of this new glass block usage. By her use of assumed values, which are essentially correct, she has shown better agreement between calculated and measured values than we might have expected.

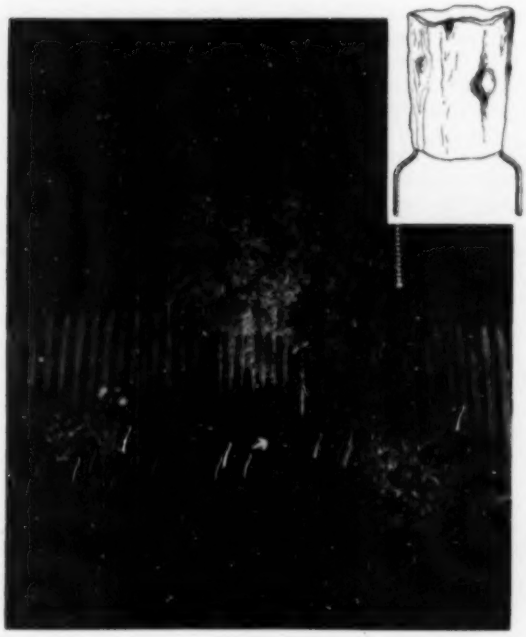
When the matter of quality is discussed, we find our technical appreciation for very low brightness ratios tempered to some degree by the architect's traditional (and continuing) desire for aesthetic objectives which are often difficult, if not impossible, to achieve within a 3 to 1, 1 to 3 brightness ratio standard. Perhaps, if more lighting people would demonstrate an active, informed interest in daylighting as has been so clearly shown here by Dr. Spencer, architects and other "daylighting enthusiasts" would be more receptive to some of the Society's recommendations. One of the best opportunities for mutual interest and cooperation is in the development of good details for combined toplighting and electric lighting elements.

Listings of I.E.S. Officers and Committee Personnel

begin on pages 17A and 24A of this issue.

Photos and sketches are from a new 48-page brochure "Garden Lighting" by Edythe Polster and Myrtle Fahsbender. For further information on this booklet, see the Book Review department of this issue.

At left, a night-lighted garden photographed through the picture window of a living room. Azaleas in full bloom are highlighted by a portable "rocklight" using a 75-watt lamp. Birch trees stand out in silvery beauty against the night sky, spotlighted from two 300-watt PAR-56 projector spots mounted on the edge of the roof line. To minimize annoying reflections on the window glass, from lamps inside the room, a series of 75-watt R-30 reflector lamps in metal reflectors are installed outside and above the picture window, providing a "wash" of light downward outside the glass. A prime rule for all garden lighting, is of course, to keep light out of your own and your neighbors' eyes. For the most part, garden lighting must be planned at night, by trial and error, to achieve just the effects wanted. Effective techniques may be developed from Christmas tree lamps up to 150-watt projectors, and telling use made of light walls and concrete surfaces as reflectors.



Above—permanently installed unit connected to underground wiring system is used for lighting steps, paths or low garden planting. Adaptable to lamps ranging from very low wattage up to 150-watt projector types, the unit is here used with a regular 75-watt lamp.

The lacy loveliness of the tree at right is dramatized against the night sky by a "tree stump" unit (see inset and arrow) using a 150-watt projector lamp. Flower beds to each side are illuminated by leaf shields using 75-watt lamps. Both types are portable and are so designed as to be quite inconspicuous in the daytime.

Garden Lighting — After Sunset

Garden lighting has its own techniques — and many new types of equipment for achieving delightful effects in either small and simple, or large formal home gardens. Several suggestions for "outdoor home lighting" effects are shown on these two pages.

Below, a portable "rocklight" using a 75-watt lamp provides accent lighting for blooming azalea. Birches in the background are highlighted from 200-watt projector spots mounted on the roof of the house. The portable unit shown at right of the trees is made with water-proof cord and plug, 60-watt yellow bulb in a glass enclosure. This may be speared into the ground anywhere in the garden, to serve as a path light, step light or for highlighting a flower bed. White light is best for flower beds, but any color except blue could enhance trellises, pools, and other garden spots.

In the photograph above, night lighting heightens the picturesqueness of a small garden pool. Latex rubber lily pads, hard to distinguish from the real thing, are clipped over submerged 75-watt lamps in special water-proof equipment, for an especially beautiful underwater effect. In the center background, a portable plastic bell-shaped unit using a 75-watt lamp is speared into the ground. Accent lighting on the right of the pool, and of the blooming flowers in the center background are from concealed 75-watt and 150-watt projector lamps in bullet-shaped units.

Photographs courtesy
Westinghouse Electric Corp.

School Lighting And Posture

By WILLARD ALLPHIN

An investigation of the posture assumed by school children when writing, made by means of unposed candid snapshots of the children in school.

GRADE-SCHOOL CHILDREN have widely differing postures — particularly when writing. The obvious need for light in order to see, and the close relationships between the eyes and other parts of the body, sometimes suggest that there may be a connection between illumination and posture.[1]

If such a connection exists, it would seem most likely to be found in writing, since it is most frequently in this occupation that children bend and twist and bring their eyes close to their work. This study, therefore, was based upon writing.

The investigation was made at the Bowditch School, Salem, Mass., and thanks are extended to Mr. Peter Carbone, Superintendent of Schools and Mr. Patrick Fallon, Principal, for their cooperation.

The building has one section 86 years old and another 45 years old. Some classrooms have windows on one side and some have windows on two sides. A gradual program of modernization is being followed, so that at the time of the study some rooms had movable furniture of light color while some had dark furniture fastened to the floor. All wall finishes are light in color. Artificial lighting is from enclosing globes, providing low illumination levels.

AUTHOR: Sylvania Electric Products Inc., Salem, Mass.

Results

The results are embodied in the photographs, which were entirely unposed. In each photograph, the child maintained the same posture while being photographed that he had before the photographer approached. Flash lamps were used in order to permit snapshots; therefore, the windows appear dark by contrast in the photographs, although there was a "cloudy-bright" sky varying in brightness from 2500 to 4000 footlamberts.

These "dark" windows certainly introduce a problem in the proper illustration of the paper. In order to expose the pictures without warning and without posing of the subjects, the use of flash was imperative. There is a temptation to retouch the

Figure 1. Grade 4; all heads tilted to left.

Figure 2. Grade 7; most heads tilted to left.

Figure 3. Grade 5; a more modern seating arrangement.

Figure 4. Grade 6; a variety of postures.

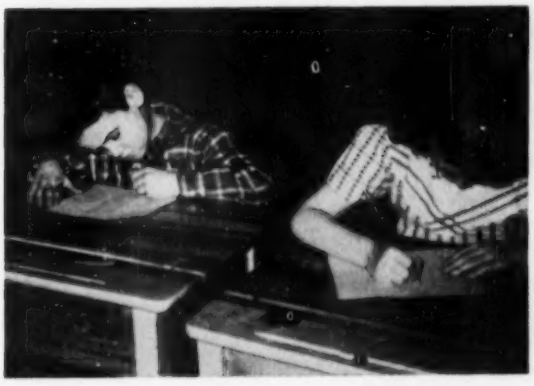


Figure 5 (left) and Figure 6 (above). Grades 4 and 3 respectively; examples of right-handed and left-handed children.

photos so that the windows will look bright — as they really were. However, this temptation should undoubtedly be resisted in a technical paper.

The alternative is for the reader to supply bright window areas from his own imagination, and this he is asked to do. Many more photographs could have been included, but they would increase printing expense without showing different results.

Analysis of Results

If the study were limited to Fig. 1, it would seem that children, when writing, tilt their heads and twist their bodies so that their eyes are exposed to less glare from the windows. Again, in Fig. 2, nearly all of the children are doing this, even though their old-fashioned desks do have tops slanted at a more comfortable angle for writing.

However, note the boy and girls in the upper center of Fig. 3, who have the windows on their right. They are tilted and twisted so as to receive more daylight glare, not less. In Fig. 4 the posture of the children seems unrelated to the window glare.

When children seated side-by-side twist in opposite directions, as in Figs. 5 and 6 it becomes evident that daylight glare is not the determining factor. The two children in each pair differ in that one is right-handed and the other left-handed, and this seems to be the real clue.

In general, right-handed children tilt to the left and left-handed children to the right, regardless of lighting considerations. This can be observed in any room where the teacher is not at the moment correcting posture.

Posture of left-handed students

Figure 7. Grade 6.

Figure 8. Grade 4.

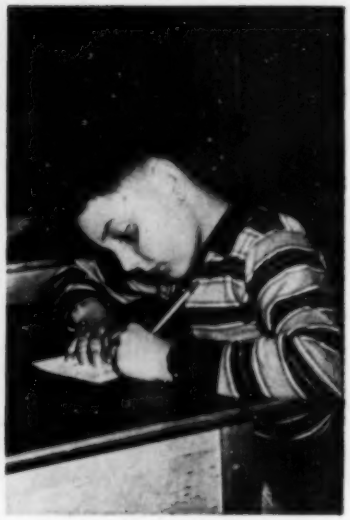


Figure 9. Grade 6.

Figure 10. Grade 8.

Figure 11. Grade 2.

Figure 12. Grade 7.

Figure 13. Grade 8.

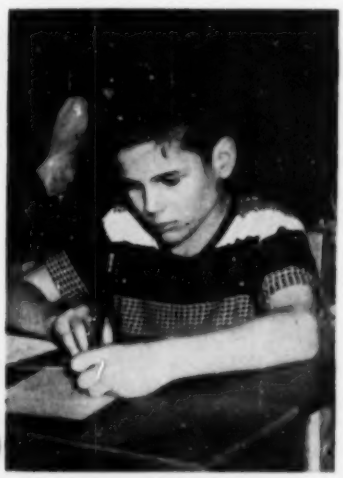


Figure 14. Grade 6.

Figure 15. Grade 2; "spring fever" posture.

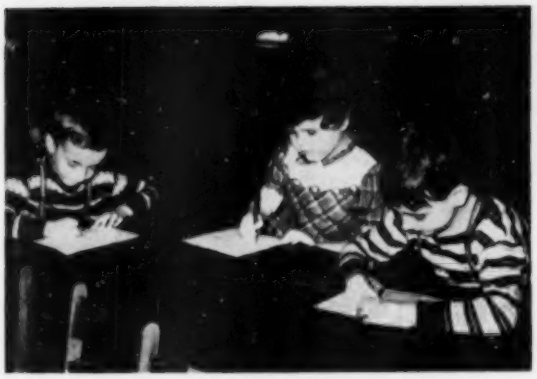


Figure 16. Grade 1; first tries at writing.

Left-handed children make interesting subjects for further analysis because they operate in an environment which is designed more for right-handed children. Nevertheless, they seem to vary among themselves over as wide a range as do right-handed pupils. The boys in Figs. 7, 8, 9 and 10, have the sort of postures we may have come to expect when left-handed people are writing, yet the girl in Fig. 10 sits erect and seems relaxed, as does the one in Fig. 11.

Further examples of pupils who show better posture than might be expected in left-handers are found in Figs. 12, 13 and 14.

Fig. 15 is included as an example of the well-known "spring fever" position, and Fig. 16 because this particular group of first graders seemed irresistible as they first begin to write.

Figure 17. Grade 5; eyes close to the work.

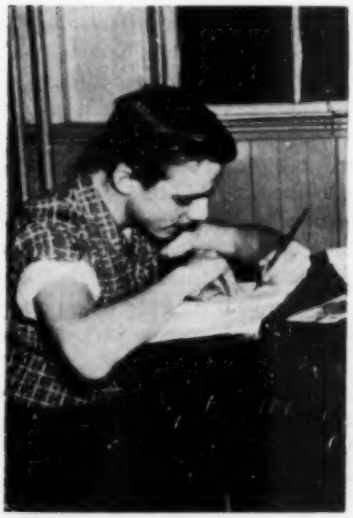


Figure 18. Grade 7: eyes again close to the work.

Figure 19. Grade 8; few eyes are really close to the work.

If daylight glare does not cause children to twist so as to reduce it, is it possible that some of the cramped positions depend upon the *amount* of light on the work? Specifically, does a low illumination level cause a child to bring his eyes close to his work? Figs. 17 and 18 do not indicate this, and many more examples could be given.

In Fig. 17, illumination on the desk nearest the window was 145 footcandles, and on the other two desks in the right of the picture was 110 and 78 footcandles yet the children have their eyes close to the paper. The desk in Fig. 18 was receiving 160 footcandles and again the eyes are close to the work. On the other hand, the girl in Fig. 10 has only 7 footcandles on her work and the one in Fig. 12 only 4, yet they are sitting erect.

As a matter of speculation, the author feels that such tilting and twisting as occurs is caused by bringing the eyes close to the work and that this closeness, when it occurs, comes from these factors:

1. The desk may be too high.
2. The pen or pencil may be held so close to the point that the head must be tilted to see under the hand.
3. Young children have so much accommodation and convergence that they can see the work as comfortably from a very close position as from a more distant one. A child who is very intent upon what he is doing may get closer and closer to his work simply because there is no reason not to.

A more important question is, "Does it do any damage?" Talks with many ophthalmologists, both in the research field and in practice, have disclosed no one who feels that permanent injury to vision will result. As Dr. Conrad Berens put it in a conversation with the author, "Except in cases of malignant progressive myopia, and these are rarely encountered, it seems so unlikely that any harm is done by bringing the eyes close to the work, that the burden of proof is on anyone who claims that it is harmful."

It might also be pointed out that children spend few of the twenty-four hours in reading or writing. A typical day at the Bowditch School is shown in the following table:

Grade	Longest Writing Period	Total Writing Time per Day
1	20 minutes	20 minutes
2	20	20
3	15	30
4	20	40
5	20	40
6	20	50
7	20	60
8	40	80

It seems doubtful that such comparatively short portions of the day would produce permanent postural defects even among those who write in presumably strained positions. Certainly the seventh and eighth grades at the Bowditch School, Figs. 2 and 19 do not indicate any worsening. A few children stoop somewhat, but they are, if anything, a smaller proportion of the class than in the lower grades.

Conclusions

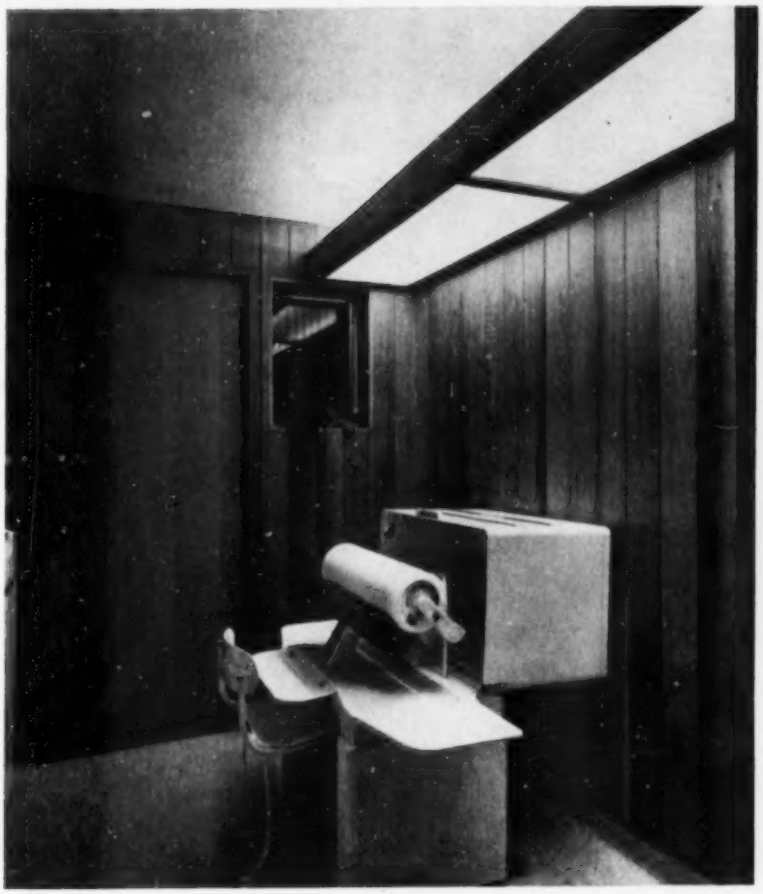
The author has no wish to minimize the importance of high illumination levels, good brightness ratios and freedom from glare. These things must certainly give a psychological "lift" which should result in better schooling, even if we cannot establish exact physiological correlations at the present state of knowledge.

As far as the subject of the paper is concerned, however, it can be concluded from observations of which the photographs represent a small but typical sample:

1. In general, there seems to be no connection between illumination and posture.
2. Specifically, school children do not adjust their posture to avoid or reduce daylight glare.

1. Harmon, D. B.: "Lighting and Child Development," ILLUMINATING ENGINEERING (April 1945).

Built-in Lighting for a Laundry — on the facing page — is one of the 15 Home Lighting Data Sheets in a new packet soon to be available. These new idea-sheets, illustrated with photographs and construction drawings, give complete descriptions of some modern methods in lighting various areas in both new and remodeled homes. The fifteen installations — all meeting the I.E.S. Recommended Practice for Residence Lighting — present new techniques for living-rooms, dining rooms, kitchens, foyers, and other living areas. The 15 sheets, in an attractive folder, will be available from the Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.



INSTALLATION AT BIRMINGHAM, MICHIGAN.

Built-in Lighting for a Laundry

LIGHTING OBJECTIVE: To provide satisfactory illumination for the ironing area in a room with a sloping ceiling.

GENERAL INFORMATION: The room is 9′6″ x 8′6″. The ceiling slopes from 8′1″ at the inside wall to 7′ at the outer door entrance. The ceiling is painted white, the panelling is bleached oak (40% reflectance) and the floor is a light mottled tan (about 55%).

INSTALLATION: Four 40-watt fluorescent lamps (standard cool white) are mounted in the custom-built canopy which is 22″ deep and extends from wall to wall. At one end this canopy becomes the top of the broom closet and thus lights this space also. Two fluorescent channels are attached to the inner side of the 4¾″ deep wood frame and the other two channels are mounted to the rear wall. The ⅛″ diffusing glass covering the bottom of the canopy is in two sections for easy handling

(over)

A.I.A. File No. 31

Figure 2. Lighting over laundry tubs.

in removal. The fluorescent lamps clear the glass by 2 inches, resulting in an even brightness across the entire glass area.

At the sink area one 40-watt (standard cool white) fluorescent unit is mounted under the wall cabinet attached to the front edge.

Illumination and brightness measurements taken after 6 months' use were as follows (readings taken with both soffit and tub lighting):

	Footcandles	Footlamberts
Ironer Roll	41	
Panelled Wall (6" below canopy)		27
Panelled Wall (6" above floor)		6
Glass Panel (from sitting position near laundry tub)		380
White Ceiling (near outer wall)		300
White Ceiling (near inner wall)		170
Floor (average)		11
Sink	43	
Cabinets above sink		8.5
General room lighting, average	7	

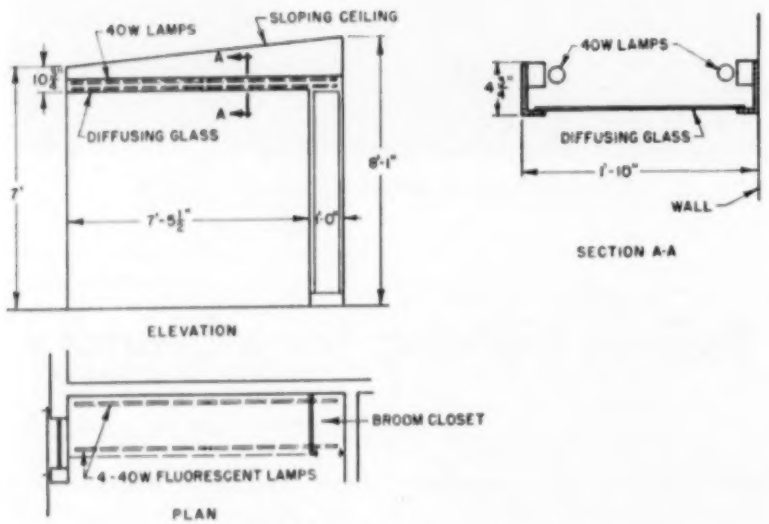


Figure 3. Installation details.

Lighting data submitted by Mary S. Taepke, Detroit Edison Company, Detroit, Michigan, as one solution to this home lighting problem and to suggest ideas which may be used in solving similar problems.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Daylighting with a New Kind Of Functional Skylight

By R. A. BOYD
JOHN LYON REID, A.I.A.

PART I

Theory and General Application of the Toplight

PART II

Lighting and Design of the Hillsdale High School, San Mateo, California

Introduction

THE proper transmission of daylight through the roof of a building is advantageous for supplementing lighting through a side wall. For large buildings with deep interiors the total light-transmitting area can be larger with respect to the floor area and the proper placement of the lighting units in the roof will provide more uniform and higher quantity daylighting. For conditions of direct sunlight the illumination of an unobstructed horizontal surface varies less over a period of one day than the illumination of the exterior walls; also, the illumination of a horizontal surface due to an overcast sky is about 2½ times that of a vertical surface.

For buildings having large floor areas and/or low ceilings adequate daylighting throughout the building cannot be provided by exterior wall fenestrations alone. Light directing glass block in exterior walls provide good daylighting for interiors up to certain depths and floor areas. Beyond these limits supplementary daylighting is required. In many such cases monitors, sawtooth units and clerestorys have been used. Most of these methods, however, have involved problems relating to glare, transmission of solar heat and leakage of water.

After more than two years of research work the Daylighting Laboratory, of Engineering Research Institute at the University of Michigan, has completed the design of a light-transmitting material for use in the roof of a building that overcomes these problems. This material is available in prefabricated panels 3 ft x 3 ft, 3 ft x 6 ft and 4 ft x 4 ft. These panels consist of hollow hermetically-sealed glass units, each 10⅝ inches square and three inches thick, set in an aluminum grid on 12-inch centers. The unit has been designated as a "toplite" and it is functional in that it is selective in its transmission of daylight and specifically distributes the transmitted light about an interior.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHORS: Daylighting Laboratory, University of Michigan, Ann Arbor, Mich., and Architect, 1069 Market St., San Francisco, Calif., respectively.

Part I

Fig. 1 shows the toplight in cross-section. The top face is plain in order that it will be washed by rain when the unit is installed with normal drainage slope. The first inside face consists of a parallel array of prisms; when the unit is installed with preferred orientation these prisms extend east and west. Their function is to control the transmission of light from the sun and sky. The lower half of the unit is so designed as to uniformly distribute the transmitted light.

The selective transmission provided by the prisms of face 2 is shown by the ray diagrams of Figs 1a, 1b and 1c, for light from a low altitude sun, a high altitude sun and for light from the north sky. One can note that for a high altitude summer sun, most of the light is reflected back toward the sun; this action, of course, limits the amount of direct sunlight and solar heat that the unit absorbs and transmits.

Fig. 2 shows the percentage transmission of the toplight for light incident in a north-south plane (that is, a normal plane at right angles to the direction in which the face 2 prisms extend). Broadly speaking, the noon time sun positions for the winter months and the summer months have been indicated; this designation is necessarily broad because of the change of sun altitude with latitude. The remaining angles of incidence, of course, pertain to light from the sky. It can be seen that the transmission of light from the north half of the sky and from the lower portion of the south sky is relatively high, whereas the transmission of light from that portion of the south sky in which the summer sun appears is substantially lower.

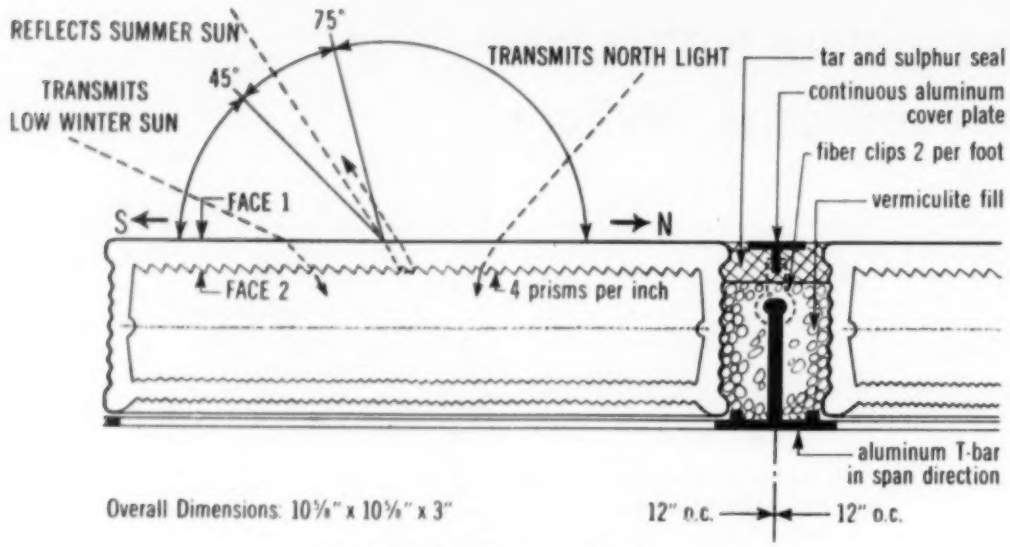
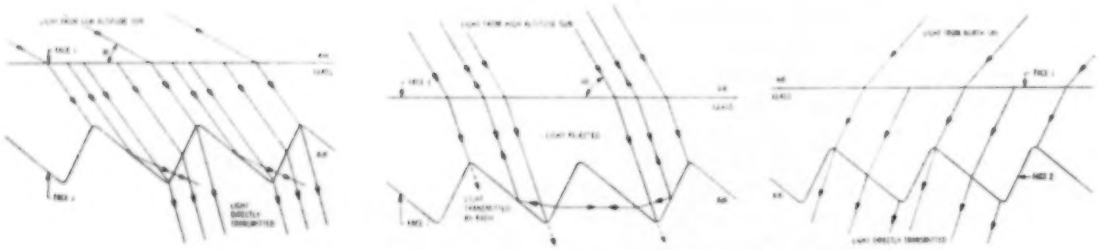


Figure 1. "Toplite" in cross-section.



Figures 1a, 1b, and 1c. Selective transmission provided by the prisms of face 2.

Applying these percentages of transmission to the amount of direct sunlight that falls on a horizontal surface at noon throughout the year at 40° N. Latitude and taking into account the transmission of light from the sky one obtains the curve of Fig. 3. This graph shows the lumens transmitted per square foot of toplight for all months of the year. It is interesting to note the constancy of the transmitted light even though the exterior illumination varies over wide limits throughout the year.

Not only is the toplight selective in its transmission of daylight but it is so designed that its brightness pattern is substantially the same for all exterior illumination conditions. Fig. 4 shows the brightness for observer's angles of view in the north-south and east-west planes for a sun altitude of 55 degrees. One will observe that the toplight does not have a maximum brightness in line with the sun, but along the perpendicular to the face; and a decrease in brightness in all directions away from the perpendicular. This type of brightness pattern is, of course, highly desirable for any toplighting unit.

It is expected that this toplight will have many applications in the daylighting of buildings, especially in providing a supplement to the daylighting from light-directing glass block in the exterior walls; Figs. 5 and 6 show two such applications.

Fig. 5 shows the daylighting, for an average overcast day, of a classroom or office that is 30 feet deep with a ceiling height of 11' 0"; the room being decorated such that the average reflectance of the ceiling, walls and floor are 85, 72 and 30 per cent, respectively. The main fenestration consists of five courses of 12-inch light-directing glass block above a shielded clear flat glass vision strip and the auxiliary fenestration is a ribbon of toplights three feet wide extending parallel to, and 6 ft 6 inches in front of, the wall opposite the main fenestration.

The shielding of the vision strip is such that its brightness is reduced to about that of the glass block panel in the direction of the room occupant,

that is, 250 footlamberts; this can be accomplished by using a gray filter of suitable density or fixed louvers of wood or metal.

One will note that for this overcast sky condition the minimum illumination of the classroom is 58 footcandles; this being near the center of the room. In addition to this being a very high minimum, for an exterior vertical surface illumination of 1000 footcandles, the maximum ratio of panel brightness to task illumination is 250 to 58 or 4.3 to 1. Thus, one sees that the quality and the quantity of the daylighting are very acceptable.

Fig. 6 shows the predicted daylighting of a factory or shopping center that has one 6 ft by 6 ft toplight panel in each 20 ft by 20 ft interior bay in addition to ten courses of twelve-inch light directing glass block, above a clear flat glass vision strip in the outside walls. The exterior illumination has been assumed to be 1000 footcandles on a vertical surface due to an overcast sky and the floor and ceiling reflectances have been assumed to be 20 and 50 per cent, respectively.

These two illustrations serve to show how the

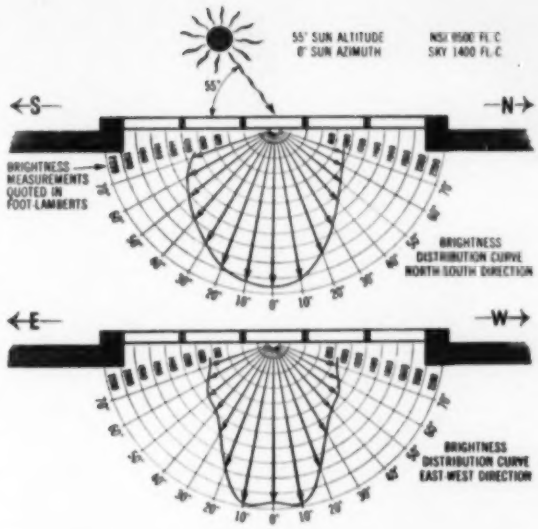


Figure 4. Brightness of "Toplite" for north-south and east-west viewing positions.

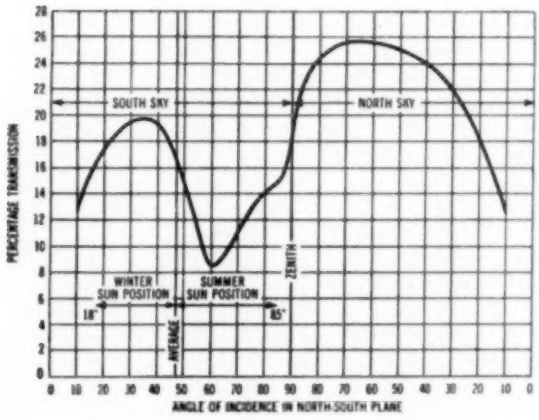


Figure 2. Transmission of light by "Toplite."

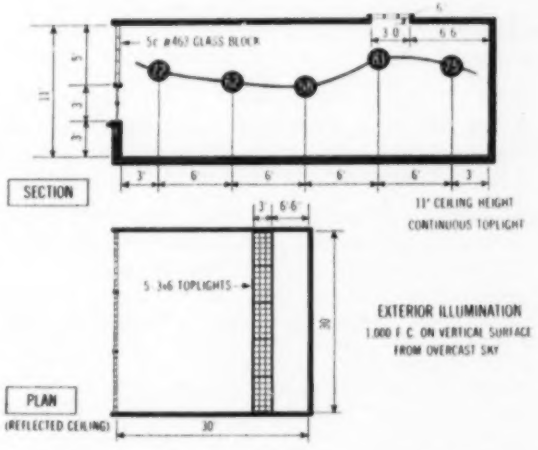


Figure 5. Illumination data for classroom or office.

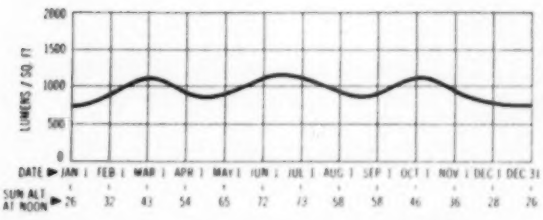


Figure 3. "Toplite" performance data at noon for entire year 40 degrees north latitude.

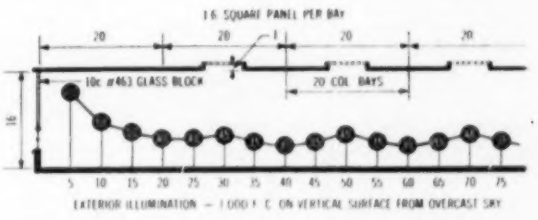

16 SQUARE PANEL PER BAY
10c #463 GLASS BLOCK
20 COL. BAYS
EXTERIOR ILLUMINATION — 1,000 F.C. ON VERTICAL SURFACE FROM OVERCAST SKY

Figure 6. Illumination data for typical factory or shopping center.

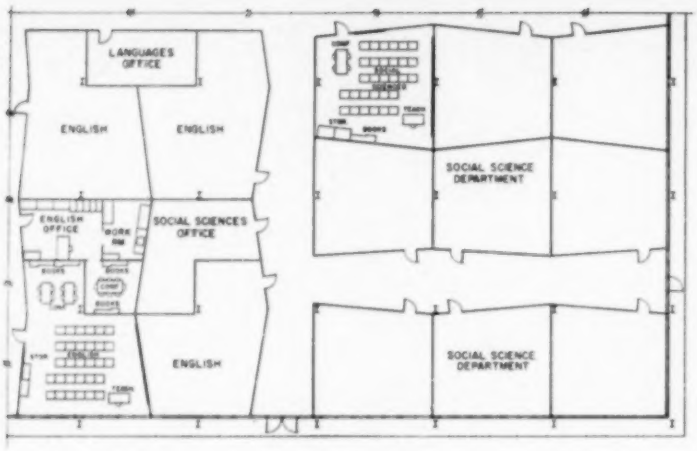


Figure 7. Typical arrangement of interior partitions.

toplite, which is glarefree and selective in transmission, can improve the daylighting of buildings. For best performance the toplights should be oriented north and south but tests have indicated that a 30-degree rotation to the east or west can be made without causing inferior performance. A drainage slope of quarter-inch per foot, in any direction except south, is recommended.

Part II

The Hillsdale High School of San Mateo, California follows a design that has been under consideration for several years. The unique plan of this school is its flexibility; that it, all interior partitions are to be movable to allow rearrangement of classrooms, laboratories, etc. to suit the changing needs of the school. Fig. 7 shows a typical arrangement of interior partitions. It is apparent that such an arrangement of rooms throughout the school allows for an appreciable concentration of building area. This plan calls for each 14 by 14 foot unit to be self-sufficient in daylighting, heating, ventilation and supplementary artificial lighting; these facilities to be supplied through the ceiling and attic space. Fig. 8 shows the coordination of these facilities within each building unit. Problems associated with the daylighting of this school were solved by the development of the toplight. Since such a plan represented a considerable departure in school design and construction, a typical classroom of the proposed school was constructed at the Daylighting Laboratory through the cooperation of the Kimble Glass Company, the Owens-Corning Fiberglas Corporation, the Martin-Perry Corporation, the Hauserman Company, the Mills Company, the Sunbeam Electric Company, the Barber-Coleman Company, LOK-Products Company and the University of Michigan. This mock-up has a floor area of 28 x 28 feet and a ceiling height of 12 feet; that is, it represents four of the basic units of the school.

Fig. 9, a photograph of the interior of the mock-up, shows the appearance of a typical classroom of the Hillsdale High School.

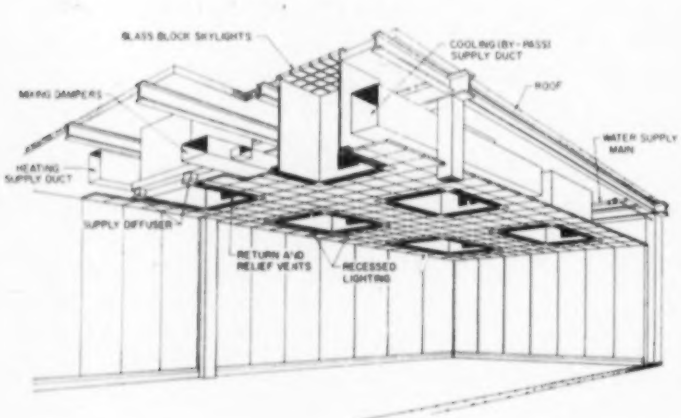


Figure 8. Coordination of facilities within building unit.

Measurements of the daylighting of this mock-up have been made periodically since it was completed on February 9, 1953. The average reflectances of the room are 80, 72 and 45 per cent for the acoustical ceiling, walls and floor, respectively. The average working plane illumination is 40 footcandles for an overcast day that provides 1000 footcandles on an exterior vertical surface and 2500 footcandles on an unobstructed horizontal surface. The ratio of maximum illumination to minimum illumination is less than 2.0; the maximum being directly below one toplite and the minimum near one corner of the room. On a clear day in February the average working plane illumination at mid-day was 120 footcandles; the diversity being substantially the same.

The quality of the daylighting is high for all exterior conditions; the maximum brightness ratio being 10 to 1 between the sides of the wells and the adjacent ceiling. The brightness ratio between the toplight and the sides of the well is 2 to 1 for an angle of view of 45 degrees.

Figure 9. Interior of the mock-up of a typical classroom of the Hillsdale High School.

DISCUSSION

E. W. CONOVER*: In discussing this paper we have two principal objections to it as a presentation of technical data.

The first is that, with the possible exception of Figs. 2 and 4, it appears to be entirely theory not backed up by test data. Figs. 3, 5, and 6 are stated to be predicted results. This implies that a prediction system based upon laboratory measurements is in existence but, to my knowledge, no such system has been published to substantiate these results. We would suggest that Dr. Boyd present his prediction method in a paper at some future meeting.

The other objection is the use of 1000 footcandles on the vertical surface as representative of that from an average overcast sky. I understand that Dr. Boyd has measured such intensities at his laboratory, but the usual practice in prediction systems is to use a common base that has been established.

In the I.E.S. Recommended Practice of Daylighting the prediction systems are based on a sky-brightness of 1000 footlamberts, which, by no stretch of the imagination would give 2500 footcandles on the horizontal. Further, the Daylighting Committee of the C.I.E. at the Saranac Lake meeting in 1928 adopted a value much lower than this for international use.

Dr. Boyd does not state how much, if any, of this 1000 footcandles on the vertical is contributed by ground reflection.

I have also a few questions on the text and illustrations. In the second paragraph it is stated that there are limits of room depth and floor area for good daylighting with glass block in exterior walls. We ask what these limits are.

We are rather skeptical of the theory that rains will wash off dirt from the upper surface of toplights. On the average, horizontal surfaces of glass are reduced to 50 per cent efficiency in about three months. We assume that the curves shown are for clean conditions. Have any tests been made on dirt accumulation? I might also ask if snow and ice would not be a problem.

Are we correct in assuming that Fig. 3 is for clear days with direct sun on the toplight? Fig. 4 seems to indicate that the brightness ratio between toplight and adjacent ceiling would exceed the recommended ratio of 20 to 1 for most viewing positions. In Fig. 5 we would like to know the minimum value at the back of the room without the toplight. Its contribution might be more impressive if a curve for the sidewall alone was shown also. The text states a ratio between the panel brightness and minimum task illumination. The comparison should be with task brightness which depends on the task reflectance. It is assumed that the section of Fig. 6 is taken through the center of the toplight panels. What would the minimum be for a section taken between the toplights?

The description of the mock-up test house for the Hillsdale School gives a floor reflectance of 45 per cent. Naturally a high floor reflectance gives best results for skylight lighting but this seems to be an impractical value for in-service floors.

In Fig. 9 the sides of the light well appear to be considerably brighter than the ceiling. The brightness ratio between toplight and sides of well is given as 2 to 1. What is it for the sides of well and adjacent ceiling?

J. W. GRIFFITH*: The authors state that the illumination of a horizontal surface due to an overcast sky is about 2½ times that of a vertical surface. The illumination of a vertical surface is dependent upon the light reflected from the ground as well as the light from the overcast sky. Therefore,

*Associate Research Engineer, Detroit Steel Products Co., Detroit, Mich.

*Director Daylighting Research, Southern Methodist University, Dallas, Texas.

the ratio of the illumination of a horizontal surface to that of a vertical surface due to an overcast sky will approach a value of 1 for high reflectance ground conditions.

Reference is made to limits for light-directing glass blocks in exterior walls beyond which supplementary daylighting is required to provide good daylighting for interiors. If the authors would state what the physical dimensions of these limits are, it would aid the architect and the illuminating engineer in their daylighting design.

The authors state that the blocks used in this toplight limit the amount of direct sunlight in solar heat that the unit absorbs. Just how much solar heat this unit absorbs and transmits and what heat load it places upon an air conditioning system would be interesting as well as informative if it is available.

Is it possible to replace one of the glass blocks used in the prefabricated panels on the job? If so, what is the approximate cost of replacing a block in a panel?

No reference is made to the amount of direct sunlight and light from the sky used to obtain the curve of Fig. 3. I would like to know if the amounts of light used were based on actual records or if the amounts were purely theoretical.

The authors failed to state which type of shielding of the vision strip was used in the test shown in Fig. 5. They have further failed to give any information on the amount of exterior vertical illumination coming from the ground. If the shielding of the vision strip were venetian blinds and the ground reflectance relatively high, a considerable amount of the 58 footcandle minimum would be due to the illumination from the vision strip for such a light overcast.

At the New York presentation of this paper, reference was made to a non-functional skylight as compared with the glass block skylight. The primary function of a skylight is to transmit light into the room. Since the relative transmission of the glass block skylight is low, possibly a better description of it would be a fixed control skylight rather than a functional skylight. Since the skylight using the glass blocks is fixed in its control, it has the same discrepancy that any other fixed control has. The occupant has no choice of daylighting conditions. The lighting requirements within a room vary with the task requirements. For this reason, it would appear that a variable control allowing the occupant to adjust the quantity and quality of illumination would be far more functional than a fixed control.

The transmission of horizontal skylights is lowered considerably by dirt collection and snow or ice building up on the skylight. This problem is partially overcome by clerestory design. In deep rooms where additional daylighting is required, this type of design appears to be more practical than the skylight.

The interior rooms shown in Fig. 7, having no exterior walls, not only deprive the occupants of the relaxation of viewing the outdoors but create a fire or disaster hazard as well. One of the best fire escapes or protection against suffocation in a building is an open window. Even in fireproof construction, interior fires as well as suffocation from smoke or gas creates a hazard and should be designed for maximum protection against these hazards. I am surprised the building code does not prohibit this type of design for schools.

It is rather surprising that a table of brightness ratios for the room shown in Fig. 9 has been omitted. The authors state that the maximum brightness ratio is 10 to 1 between the sides of the wells and the adjacent ceiling. If the sides of the wells are just 10 times brighter than the adjacent ceiling, the illumination on the side walls must be low. With low levels of illumination on the side walls, it would appear that the room would have very poor brightness ratios, particularly between the desk tasks and the dark chalk boards on the walls.

H. B. VINCENT*: I must, of course, congratulate the authors on the presentation of an excellent paper on a very interesting new product. I have two or three questions to ask.

(1) In the use of skylights, one of the more difficult problems has been to provide an installation which shows no leakage of water from rain or melting snow. Does the "toplite" leak?

(2) Another problem with skylights is that in warm summer weather they may admit a substantial amount of radiant heat from sunlight, making building interiors uncomfortably warm. How does the new product perform in this respect?

(3) The design of the Hillsdale High School, with no daylighting through exterior walls, is obviously unconventional. Does this structure provide as good economy as a conventional design?

R. W. MCKINLEY**: The authors can be proud of their contribution to the rejuvenation of a good idea. It is generally agreed that the simplest way to provide high and uniform daylighting levels is by introducing light from overhead in accordance with common electric lighting practice. The fact that there is more light available on near horizontal surfaces than on near vertical surfaces is especially true on very dark days when the need is greatest.

In their enthusiasm for an intriguing new approach to the skylight problem, I hope they will not leave un-discussed for this audience three practical problems that have greatly restricted the development of skylights in the United States. These are heat gain, water leaks and cost.

To encourage sober discussion of these problems I present the following questions:

(1) In an air conditioned space what is the proper figure to use for estimating cooling load in terms of BTU/sq. ft. of shaft area per hour on the usual August 1st design day?

(2) Since the energy paths for light from high summer sun altitudes are approximately twice the length of those for light from low and north incident angles as shown in Figure 1, it seems to me that the top segment of the block must become very hot during the summer as a result of energy absorption. Will not these high temperatures cause the tar and sulphur caulking material to flow through the structural web and thus cause leaks as well as a mess on any objects which it happens to fall on? I have seen this happen in an earlier type of skylight using a similar mastic. Please tell us what temperature the top segment is likely to reach on a clear, sunny, summer day and what the softening point of the tar and sulphur is.

(3) What is the approximate installed cost of these panels per square foot of shaft opening to a building owner who already has the proper curbing erected?

It would be helpful if the authors would provide data comparable to that given in Figs. 2, 3, 4, 5 and 6 for panel orientations 30 degrees and 45 degrees removed from the north-south axis. Site and structural problems will often make these departures necessary. Also, I would like to ask how the optical performance will be affected by accumulated dust, dirt and roughening of the top surface by foot traffic and cleaning over a period of time.

*Owens-Illinois Glass Co., Toledo, Ohio.
**Pittsburgh Corning Corp., Pittsburgh, Pa.

DOMINA EBERLE SPENCER*: The data on the transmitting characteristics of the new toplight are presented in an informative and attractive fashion. The material on the effect of various outdoor conditions is of definite value. But if lighting designs are to be made with toplight units, further data are needed:

(1) Equivalent ceiling reflectance of toplight,

(2) Transmittance in ultraviolet and in infrared,

(3) Pharos ratios as measured by Losh[1] (so that the interflection method can be used without assuming a perfectly diffusing toplight).

It is also good to see that quality is treated in a quantitative fashion. The production of a satisfactory luminous environment, however, is not taken seriously enough. If we compare the adaptation helios for the work with the helios of the small toplight panels, we find that the 3:1 ratio *is not satisfied.* Because the adaptation helios ratios are too high, both direct and reflected glare will be experienced. The pattern of light on the ceiling is similar to that obtained with troffers. This has been found unsatisfactory in office and school lighting practice at 50 lumen ft.$^{-2}$. As much higher illuminations will be available on sunny days, there is even more chance of trouble here. For it is a well-known fact that the eye is much less tolerant of non-uniformities in the field of view when the state of adaptation is raised.

The glass block are said to be self-washing! I wonder if this is more than a pious hope. Certainly our automobiles and the windows on our buildings are not self-washing. It is hard to see how a magic slope of ¼ inch per foot can wash the "toplite.'" The pessimistic observer is tempted to expect that a daylighting system designed for 40 lumen ft.$^{-2}$ on a cloudy day will give more nearly 4 lumen ft.$^{-2}$ (at least in a dirty location and a dry season). Thus adequate artificial lighting cannot be dispensed with.

Perhaps the most serious difficulty with the toplighting system is that it interferes with the artificial lighting. The recessed spotlights shown in Fig. 8, provide a maximum of direct and reflected glare and a minimum of visual effectiveness. Thus, both the daylighting and the artificial lighting of the typical classroom described in the paper fail to satisfy modern quality criteria.

1. John A. Losh: "Rectangular Coordinate Photometer for Large-Area Luminaires," I.E.S. 1953 Conference Paper No. 24 (to be published).

R. A. BOYD**: It is gratifying to have so many remarks made regarding this paper. I shall attempt to reply to all of the questions, but not necessarily in the order in which they are presented because there is considerable duplication.

In reply to Mr. Conover, all of the material presented in the paper was based, to some extent, on test data. Figs. 2, 3 and 4, of course, are based upon data collected on a single block. The illumination data for the classroom or office of Fig. 5 were obtained by measurements made in a scale model. The data of Fig. 6 were obtained by measurements in two models, one having a main fenestration consisting of light-directing block and the second, a toplight fenestration. These data were then adjusted in intensity and combined as shown by Fig. 6. It is true that we do have a prediction method that is applicable to light-directing block and the toplight. Unfortunately, this material is not yet in a form suitable for publication but it is expected that it will be ready for presentation in the not too distant future.

Mr. Conover again brings up the question of the suitability of a vertical-surface illumination of 1000 footcandles, due to an overcast sky, as being representative of average conditions. It is unfortunate that the laboratory has not completed the survey of meteorological conditions so as to publish the data upon which we base our opinion. It is expected that this material will be ready for publication within the next year or so. The vertical-surface illumination of 1000 footcandles that has been used in this paper was considered to be entirely due to direct light from the sky and did not include any contribution from ground reflections. A theoretical consideration of vertical and horizontal surface illuminations, due to an overcast sky, indicates that the horizontal value is approximately two and one-half times the vertical value if no ground reflected light is included. Mr. Griffith indicates that the ratio of horizontal to vertical would approach unity for high-reflectance ground conditions. This is not true if one assumes that the ground acts as a perfect diffuser. Even if the ground-reflectance was one hundred per cent, then the vertical surface illumination would only reach about nine-tenths of that of the horizontal.

In reply to Mr. Conover, it has been our experience in using light-directing glass block in exterior walls, that one can daylight a room satisfactorily to a depth approximately equal to twice the ceiling height. Beyond that, we realize that a secondary daylighting source is required.

In order to have some opinion as to the reduction in transmission of the toplights, due to an accumulation of dirt, several block in a horizontal position were allowed to collect dirt in an industrial area for a period of seven months. These tests indicated that a smooth-faced block showed a fifteen per cent reduction in transmission, whereas a rib-faced block indicated a thirty per cent reduction in transmission. As regards the effect of snow and ice, it is our feeling that even though the toplight is a good insulator it will transmit enough heat from the interior to dispose of these in a relatively short period of time.

Fig. 3 shows the noontime performance data for clear days at 40 degrees North Latitude.

Mr. Conover says that Fig. 4 seems to indicate that the brightness-ratio between the toplight and the adjacent ceiling would exceed the recommended ratio of 20 to 1 for most viewing positions. It seems to me that it is apparent that such a ratio cannot be determined from a brightness diagram such as that shown by Fig. 4 because the brightness of the adjacent ceiling depends upon the percentage of the ceiling that is fenestrated, as well as upon the reflectivities of the various room surfaces. As stated in the text of the paper, the brightness-ratio between the toplight and the sides of the walls was 2 to 1, whereas, the brightness-ratio between the sides of the walls and the adjacent ceiling was 10 to 1, thereby indicating an overall ratio of about twenty to one. In this mock-up of the Hillsdale High School, we realize that the floor reflectance was somewhat higher than is usually encountered. At the same time, this is necessary in a room that is completely toplighted in order to reduce the brightness-ratios referred to above. It is our feeling that floors having higher reflectances are becoming much more accepted than they were a few years ago. Most of the reluctance to the lighter floors came from the custodians and now they are realizing that it is no more difficult to keep a light-colored floor clean than a dark-colored one.

Several of the discussors mentioned the leakage and solar heat problems that are usually associated with skylights.

As regards leakage of water; this method of prefabrication has been used by the American 3-Way Luxfer Prism Company of Chicago for about five years and, consequently, they have had an appreciable amount of experience. Since the panels are prefabricated in the factory, the chances of

*University of Connecticut, Storrs, Conn.
**Author.

leakage through them is much less than if the fabrication was done on the job. Setting these panels on a prearranged curb and flashing them down to the roof is a relatively simple job. During the five years that American 3-Way have been installing this type of panel they have not had any complaints regarding leakage.

As regards the transmission of solar heat; we have not actually completed any direct measurements but we do have some results that were obtained by calculations that were based on best available physical data. These calculations were made by Professors C. O. Mackey and R. R. Gay of Cornell University, who are recognized authorities on heat gain. These calculations were made for August 1 and September 7, at 37 degrees North Latitude and the maximum values of instantaneous solar heat gain were 70 and 40 BTU per square foot per hour, respectively.

Mr. McKinley also questioned the melting point of the tar and sulphur compound that is used in sealing the panels. This is sufficiently high that even on the warmest days during the summer there will only be a softening of the top surface. We do not have actual tests on the temperature this material might assume on a clear-sunny summer day.

Also, Mr. McKinley requested an approximate installed cost of these panels per square foot and we regret that we are unable to supply such figures at this time.

As regards the effect of rotating these panels 30 to 45 degrees from the preferred north-south axis, our tests indicate that a rotation of 30 degrees can be provided and the increase in the transmission of luminous energy will not be more than 10 per cent for regions within the United States. A rotation of 45 degrees, however, in the southern latitudes may cause an increase of as much as 30 per cent.

Mr. Griffith asked about replacing one of the glass blocks in one of the prefabricated panels. It is possible to do this by removing the broken block, cutting back the tar and sulphur and the Vermiculite and recaulking and sealing with the tar and sulphur material. We do not have an approximate cost, however, for such a replacement job.

The amounts of direct sunlight and light from the sky used to obtain the curve of Fig. 3, were obtained from meteorological considerations. The figures that we have drawn up are considered to be average values for most of the United States and we feel that they should be increased by about 10 per cent for states such as Texas and California and should be decreased by about 10 per cent for the larger industrial cities.

Mr. Griffith makes reference to the shading of the vision strip in the classroom shown by Fig. 5. In the model that we used, this shading was actually accomplished by a sheet of gray Plexiglas and, of the 58 footcandles, 4 footcandles was due to light from the shielded vision strip. This component, of course, was segregated by completely shading the vision strip. Other materials that we have used for control of vision strip brightness include Koolshade Screen and the new Dusklite that is manufactured by the Pittsburgh Plate Glass Company.

Mr. Griffith also questions the use of the word "functional" with skylight. We have thought of this adjective as descriptive of the performance of the material that constitutes the light-transmitting area. In the case of the "Toplite," the controls consist of the array of prisms and these, of course, alter the transmission, depending upon the location of the sun. It is true that this control is not adjustable in the sense that a venetian-blind is adjustable yet its effect varies, depending upon the exterior illumination conditions. It has been our experience that if a visual environment is made satisfactory from the quality point of view, then the variation in requirements for various tasks is much less important.

Mr. Griffith indicates the possibility of a clerestory design being superior to an arrangement of horizontal skylights, due to the reduction in transmission of the latter brought about by dirt collection and snow and ice. As indicated previously, the horizontal surface, on an overcast day, may have from 2 to 2½ times as much light on it as a vertical surface. Therefore, on an equal area basis, the reduction in transmission could equal 50 per cent for the horizontal before the illumination potential of the two areas would be equal. This is completely disregarding the fact that the horizontal skylights can be placed more strategically with respect to the working plane.

Both Dr. Vincent and Mr. Griffith raised a question regarding the architecture of the Hillsdale High School. Although John Lyon Reid has left it up to me to present the rebuttals to these discussions, I would like to include two paragraphs that he supplied relating to the construction of the building:

> "The first point is, that toplighting provides us with an opportunity to divorce the interior spaces of the building from any relation to an outside wall. We do not depend on conventional fenestration for good daylighting. This consideration frees us completely from any limiting dimensions for the building; this in turn means that large rooms, or small rooms, of almost any dimension can be arranged with the assurance of securing good daylighting in all spaces. We now are able to design a building with complete flexibility of room sizes, shapes, and relationships. Complete flexibility for rearrangement is now possible which is a great advantage, particularly in secondary schools.
>
> "The other advantage is that we are able to eliminate courts and to condense the building area on the site. This is an important planning consideration when sites of limited area are involved. In addition to that, we are able to reduce to a minimum the length of outside perimeter walls for a given area of building; the outside walls cost considerably more than partitions and require insulation against heat loss. The reduction in the length of perimeter walls is a cost saving in construction and the condensation of the shape of the building represents shorter utility pipe runs, and the reduction of outside walls reduces heat losses; all the above should result in a more economical type of building."

Although Dr. Spencer did not present her discussion at the time of the Conference, she was kind enough to present written material and I shall do my best to reply to her. Dr. Spencer indicates the need of additional information on the toplight units. We only have information on the first item. The equivalent ceiling reflectance of the toplight is approximately 35 per cent. We do not have any information on the transmittance in the ultraviolet and infrared regions other than that which is usually available on the glass itself. We have not measured the pharos ratio, as measured by Losh. The type of measurements that we obtain on a single block are those indicated by Figs. 2 and 4 of the paper.

Dr. Spencer also refers to the accumulation of dirt and I have already commented on that above. Also, she makes reference to the artificial lighting that is shown in the photograph of the mock-up of the typical classroom of the Hillsdale High School. The Daylighting Laboratory did conduct some additional tests on the artificial lighting, most of which pertained to location. I have not heard from John Lyon Reid as to final arrangements for artificial lighting.

INSTALLATION AT De NARDO JEWELRY STORE, BRADDOCK, PENNSYLVANIA.

Lighting a Jewelry and Appliance Store

LIGHTING OBJECTIVE: To provide general lighting and highlight merchandise in a small store.

GENERAL INFORMATION: This store measures approximately 100 x 15 feet; ceiling height is 12½ feet. The side walls are green (30% RF), ceiling is white (80% RF), floor is green and yellow tile (30% RF) and the work surfaces are all glass.

INSTALLATION: Fig. 2 shows a plan view of the front part of the store. The layout of the rear is similar. After two years' operation with complete cleaning twice a year the illumination was as follows:

Average from fluorescent lighting	55 ft-c
Under downlights (with fluorescent on also)	230 ft-c
Vertical surface of side displays,	
6 feet above floor	75-100 ft-c
Silver case with glass doors	
On vertical glass	75 ft-c
Behind glass	45 ft-c

(over)

A.I.A. File No. 31

Lighting a Jewelry and Appliance Store (continued)

Brightnesses measured:

Glass-bottom troffers	450-ft-L
Recessed spot units (on side of louver at 45°)	75 ft-L
Ceiling between luminaires	20 ft-L
Upper walls	12 ft-L
Rear wall	10 ft-L
Wood trim around cases	7 ft-L
Floor	35 ft-L
Wall cases, interior	45 ft-L

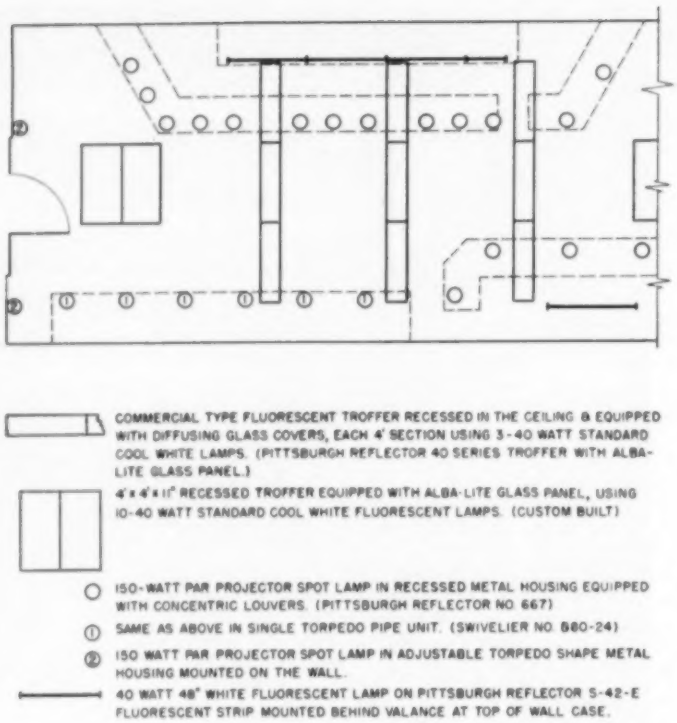

COMMERCIAL TYPE FLUORESCENT TROFFER RECESSED IN THE CEILING & EQUIPPED WITH DIFFUSING GLASS COVERS, EACH 4' SECTION USING 3-40 WATT STANDARD COOL WHITE LAMPS. (PITTSBURGH REFLECTOR 40 SERIES TROFFER WITH ALBA-LITE GLASS PANEL.)
4'x4'x11" RECESSED TROFFER EQUIPPED WITH ALBA-LITE GLASS PANEL, USING 10-40 WATT STANDARD COOL WHITE FLUORESCENT LAMPS. (CUSTOM BUILT)
150-WATT PAR PROJECTOR SPOT LAMP IN RECESSED METAL HOUSING EQUIPPED WITH CONCENTRIC LOUVERS. (PITTSBURGH REFLECTOR NO. 667)
SAME AS ABOVE IN SINGLE TORPEDO PIPE UNIT. (SWIVELIER NO. 680-24)
150 WATT PAR PROJECTOR SPOT LAMP IN ADJUSTABLE TORPEDO SHAPE METAL HOUSING MOUNTED ON THE WALL.
40 WATT 48" WHITE FLUORESCENT LAMP ON PITTSBURGH REFLECTOR S-42-E FLUORESCENT STRIP MOUNTED BEHIND VALANCE AT TOP OF WALL CASE.

Figure 2. Plan view of front section of store.

Architect: Casmir J. Pelligrini, Pitsburgh; John B. Martin, Duquesne Light Company representative.

Lighting data submitted by A. G. Caplan, Duquesne Light Company, Pittsburgh, Penna., as an example of good lighting practice and to aid in the design of similar installations.

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Daylighting With Plastic Domes

By BERNARD F. GREENE

Introduction

WINDOWS have been used for a long time, yet the concept of daylighting design is relatively new. Architects and engineers are now becoming increasingly aware of the value of careful design of interior spaces for proper daylighting, for a good daylighting arrangement pays dividends throughout the life of a building.

The source of daylight is the sun and sky, and much is known about the variation of sky brightness and intensity. By utilizing the known data of sky brightness, and with the proven formulae for calculating illumination from surface sources, it is possible to obtain the illumination for any daylighting arrangement.

The first step toward the design of an engineered daylighting arrangement is establishing the source brightness. The actual sky brightness in any location varies with weather conditions, with the time of day and time of year, and it is necessary to assume a certain minimum value of sky brightness. The value chosen for most all calculations is the sky brightness on an overcast day, resulting in a horizontal illumination of 1000 lumens per square foot. For a uniform sky brightness this is equivalent to a vertical illumination of 500 lumens per square foot. This value of sky brightness is, in general, available at least 85 per cent of the daylight working hours throughout the year, in the area about 42 degrees latitude. Using this value, the illumination and brightness at any point in a room can be calculated from any daylight source.

Plastic Domes as Daylight Fixtures

Whenever it is possible to open a roof to the sky the daylighting within the room can be designed to provide uniform glare-free illumination. The amount and distribution of the daylight can be controlled by varying the size and quantity of fixtures on the roof.

The daylight fixtures to be discussed in this paper are plastic domes. (Fig. 1) The unit is a skylight consisting of a plastic dome surrounded by a metal frame. Domes, as manufactured by the Wasco Flashing Company, are factory assembled, packaged units, available in a large variety of square, rectangular and circular sizes. Circular units are available in 3-, 4- and 5-foot diameters, square units in 2-, 3- and 4-foot squares, and rectangular units in sizes ranging from 2 x 2½-foot, to 5 x 8-foot. The domes are vacuum drawn from a single piece of a thermoplastic acrylic plastic. This type of material is used because of its high light transmission, good light diffusion properties, resistance to breakage and shattering, light weight, and its ability to withstand outdoor weathering. Domes are available fabricated of either clear or white translucent plastic. However, for almost all daylighting applications, the translucent plastic is used. The thickness of the plastic dome varies between $\frac{3}{16}$ inch and $\frac{5}{16}$ inch depending upon the size of dome used. The diffuse transmission of the acrylic plastic type 122-50, is $\frac{3}{16}$ inch — 55 per cent and ¼ inch — 48 per cent. The dome or bubble shape has proven to be most desirable because of its high strength, pleasing appearance, and good maintenance.

Experiments have shown that better maintenance is obtained when the surfaces are angled away from the horizontal. The formed shape allows for self-cleaning by rain, and also serves to reduce the possibility of accumulation of snow and ice. For clean localities, the assumed maintenance factor for skydomes is 70 per cent.

Dome Calculations

The light distribution from a single translucent dome, can be assumed as being similar to that from a surface source. This applies whether the primary source of light is an overcast sky or a clear sky together with direct sunlight which is diffused by

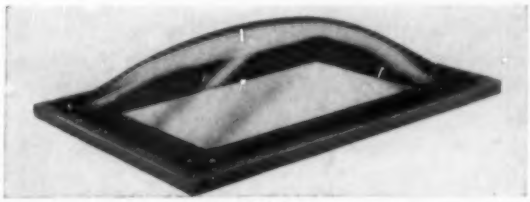
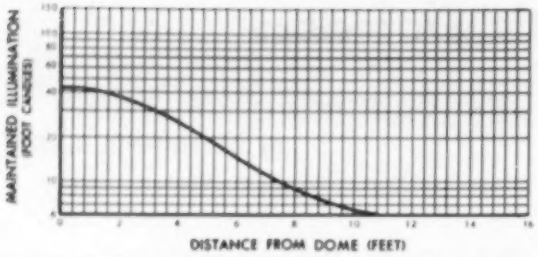


Figure 1. A typical clear plastic dome in its metal frame.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHOR: Consulting Engineer, New York, N. Y.



CURVE OF ILLUMINATION VERSUS DISTANCE FROM DOME

Figure 2. Illumination distribution from a single 4-foot-square translucent dome. The assumed sky brightness was 1000 ft-L.

the white plastic. Using the curves calculated for obtaining illumination from a surface source[1] the light distribution curve (Fig. 2) was obtained. This curve was calculated for a 4 x 4-foot translucent dome, assuming an equivalent sky brightness of 1000 footlamberts, and a mounting height of 10 feet above the working plane. In this instance the effect of room reflectance, and of the light well in which the dome is mounted, was not considered. Where a number of domes are used, then the illumination can be obtained either by point by point calculation using calculated distribution curves of single units, or by use of the interreflection method.[2] When domes are the sole source of illumination, then the interreflection method is the most convenient to use, as it allows for different room reflectance. An example of the interreflectance method as applied to a dome application is as follows:

Example: Assume a room 30 x 30 feet, 15 feet high, with ceiling, wall and floor reflectances of 70, 50 and 10 per cent. Sky brightness, 1000 ft-L. Calculate illumination and brightness from four 4 x 4-foot domes, installed at quarter points in room, in a 24-inch deep white well.

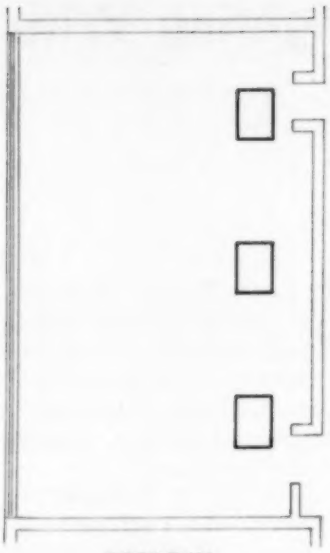
Calculated $k_r = .50$; Interreflectance = .66
Dome efficiency = $.87 \times .48 = .42$
Maintenance factor = 70 per cent
Maintained illumination =

$$\frac{.66 \times .42 \times .70\,(1000 \times 4 \times 16)}{30 \times 30} = 13.6 \text{ lumens/sq. ft.}$$

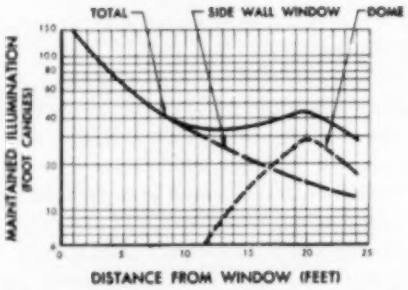
Dome brightness = $1000 \times .48 \times .70 = 336$ ft-L
Wall brightness (midway between floor and ceiling) = $.34 \times 13.6 = 4.64$ ft-L

Ceiling brightness (average) = $1.71 \times 13.6 = 23.4$ ft-L

Floor brightness (average) = $.083 \times 13.6 = 1.1$ ft-L



FLOOR PLAN



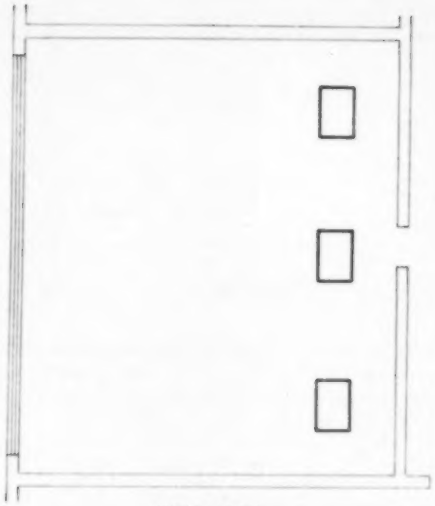
CURVE OF ILLUMINATION VERSUS DISTANCE FROM WINDOW

Figure 3. Classroom with sidewall windows. Window height is 7 feet with a 4-foot overhang. Three 3 x 4-foot domes are used for supplementary lighting.

Dome Application

Domes have been found to be effective for complete daylighting of an interior and as an adjunct to side wall windows. With unilateral side wall fenestration, the illumination is at a maximum near the window and decreases as the distance from the window increases. With a daylighting fixture such as the dome, the daylight can be put where needed, so as to result in a uniform illumination distribution. (Fig. 3)

For rooms without sidewall windows, the domes can be placed uniformly throughout the area, similar to the design of an artificial lighting system. In general, the spacing between domes should not exceed 1½ times the ceiling height, while the spacing between the first row of units and the wall should be ½ of this value. For the large size dome units



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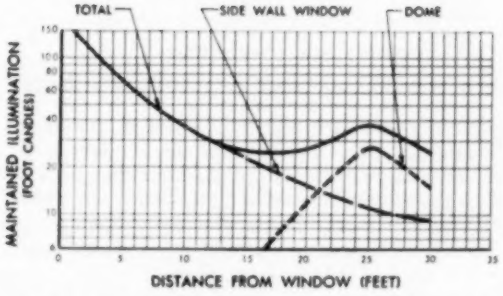
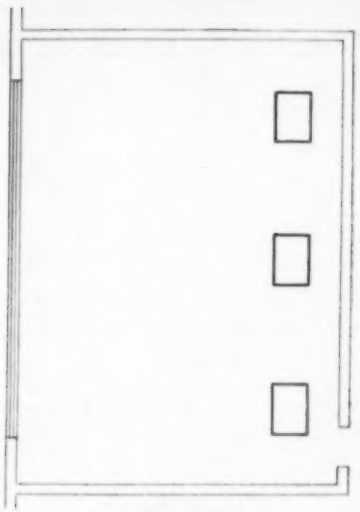


CURVE OF ILLUMINATION VERSUS DISTANCE FROM WINDOW

Figure 4. Classroom with sidewall windows in which domes are used for supplementary illumination. Window height is 7 feet, and there is a 4-foot overhang. Three 3 x 4-foot translucent domes are used to give illumination distribution as shown in the graph.



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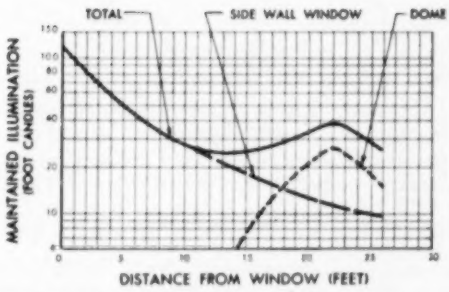


CURVE OF ILLUMINATION VERSUS DISTANCE FROM WINDOW

Figure 5. Classroom with 6-foot sidewall window and 5-foot overhang. Three 3 x 4-foot translucent domes are used.

the spacing can be up to twice the ceiling height. Where the task to be illuminated is high above the floor, such as rows of bins in a warehouse, the spacing between units should be reduced.

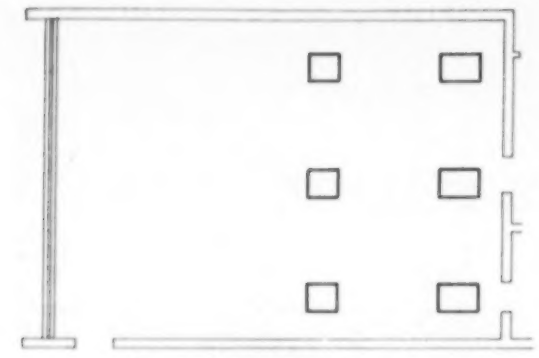
Each installation has to be considered separately. The domes have to be arranged to give uniform illumination of the required intensity. For the most economical design the smallest number of units should be used, as the larger units are more efficient.

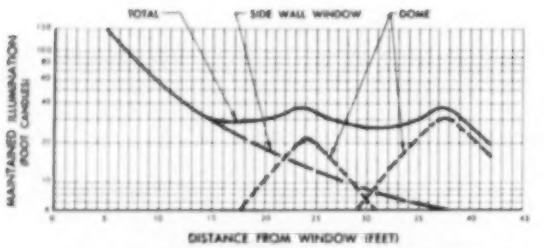
Figs. 4, 5, 6 and 7 illustrate the use of domes as an adjunct to side wall lighting. It will be noted that the domes fill in with daylight where the side wall illumination drops off. Where the room is not deep in comparison with the window height, one row of domes is all that is required (Figs. 4 and 5). For deep rooms in comparison to the window height, two or more rows of domes should be used. (Figs. 6 and 7) The required number of domes also varies with the room length, as the wider the side wall window, the greater is the light penetration into the room.

The illumination distribution curves given in the acompanying graphs indicate the average distribution across the room width.

A special application of daylighting in an area without side wall windows, such as a corridor, is shown in Fig. 8. Since this is not a work area, complete uniformity of illumination is not essential, and dome installations have been made with spacings up to three times the ceiling height.

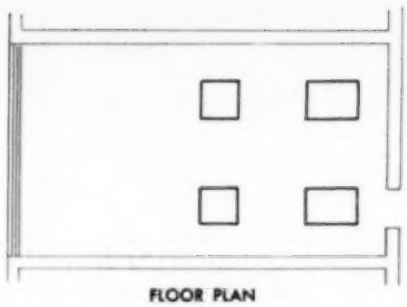
Dome daylighting fixtures have been installed in rooms where there are windows on both walls, and in which the room width is such that proper illumination could not be obtained in the center of the area. An example of this type of installation is shown in Fig. 9.

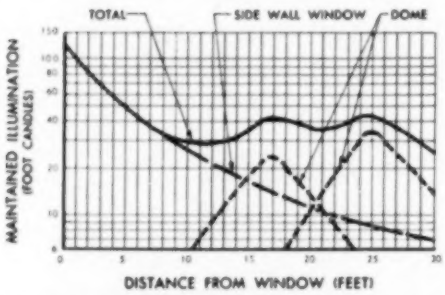




CURVE OF ILLUMINATION VERSUS DISTANCE FROM WINDOW

Figure 6. Classroom with 7-foot high window on one wall. This room, due to its depth, requires two rows of translucent domes, one row of 3-foot-square units and one row of 3 x 4-foot units. Distribution is as shown on the graph.





CURVE OF ILLUMINATION VERSUS DISTANCE FROM WINDOW

Figure 7. Two rows of domes are required in this deep, narrow drafting room. The first row consists of two 3-foot-square translucent domes and the second row of 3 x 4-foot domes. Window heinght is 7 feet with 6-foot overhang.

There have been many examples of installations of domes in windowless buildings. Daylighting studies showing the design and application of domes for windowless areas are shown in Figs. 10, 11, and 12.

Ceiling domes are sometimes used with skylight domes. The ceiling dome is a translucent plastic bubble mounted in a frame. It is installed at the bottom of the skylighting well, flush with the ceiling (Fig. 13). Ceiling domes are used to further reduce the brightness, to give additional insulation in extremely hot or cold areas, and for concealment of artificial lighting fixtures.

Daylighting and artificial illumination can often be architecturally integrated. Three schools were designed for Portchester, New York, in which this was effectively accomplished (Fig. 14). The archi-

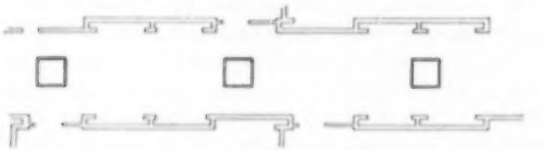


Figure 8. A corridor illuminated with 3-foot-square translucent domes. Design level of illumination is 18 ft-c.

Figure 9. In this large warehouse area, with windows on two opposite walls, two rows of 3 x 4-foot translucent domes are required. These are placed, as shown, in the center of the area. Design level of illumination is 9 ft-c average.

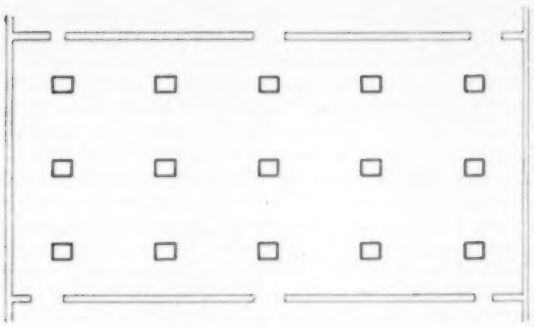


Figure 10. A warehouse without sidewall windows. Daylighting design uses fifteen 3 x 4-foot translucent domes to give an average maintained illumination of 13 ft-c.

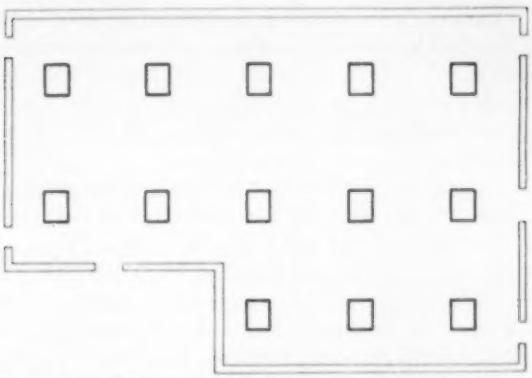


Figure 11. Thirteen 5 x 6-foot translucent domes are used to illuminate this factory area. There are no sidewall windows. Installation is designed for 35 ft-c.

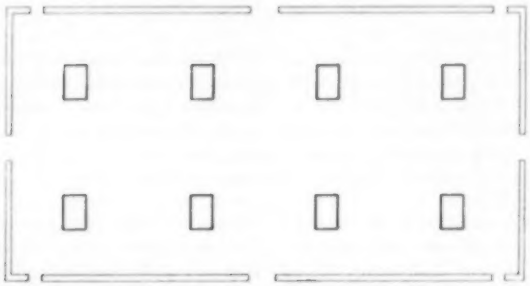


Figure 12. A pool area with no sidewall windows. Eight clear domes, 5 x 8-foot, are used to illuminate the area to an average maintained value of 28 ft-c.

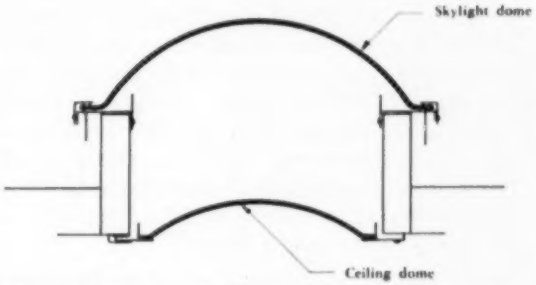
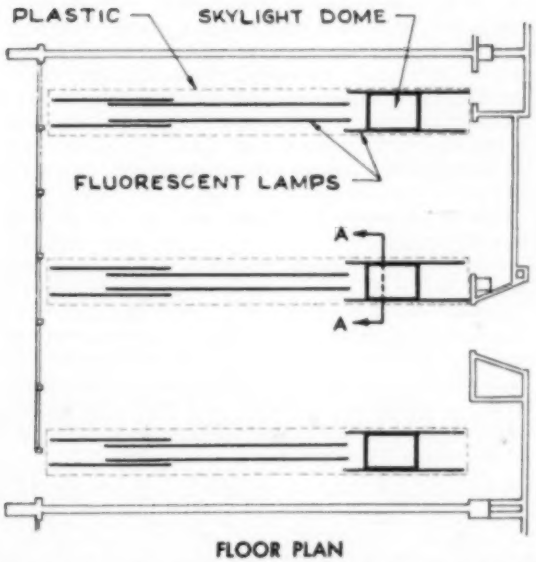


Figure 13. Cross-section illustrating a combination dome and ceiling bubble arrangement.



tects for the job were Sherwood Mills & Smith; the mechanical engineers, the firm of B. F. Greene. Domes and fluorescent strips are mounted above translucent plastic panels. The plastic panels are mounted on the roof joists.

Economics

Engineering for daylight is more than compensated for by availability of good light throughout the day. It is also possible to illustrate that the

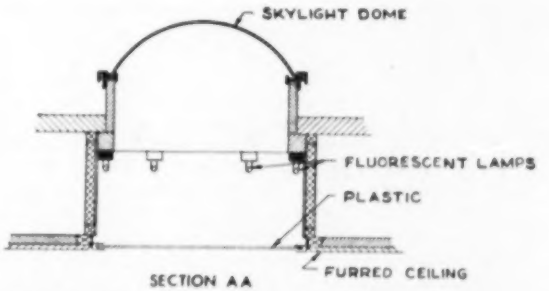


Figure 14. Classroom in which daylighting and artificial lighting have been integrated. Domes and fluorescent lamps are mounted above translucent plastic panels.

added costs for installing a daylighting fixture can be offset by the resulting saving in electrical energy costs. It will be noted that only energy costs are considered as it would be necessary to install a complete artificial lighting system to take care of the dark days and night-time usages.

As an example of a cost comparison, let us take a room 75 feet long, 50 feet wide and 20 feet high. The reflectance of the ceiling is assumed to be 75 per cent and the wall reflectance 50 per cent. To obtain 30 lumens per square foot, ten 5 x 8-foot domes are required. The cost of these units installed is in the order of $4000. The cost of roofing, which would have to be installed in place of these units is approximately $500.

To illuminate this room to the same level using fluorescent luminaires would require a total of 8000 watts. Assuming a usage of 250 days per year, 8 hours per day, and an energy rate of 3 cents per kilowatthour, then the annual energy cost is $480. The lamp cost would be approximately $120. The cost of artificial illumination during the days in which insufficient daylight will be available is taken as 15 per cent of ($480 plus $120) or $90. The time required to pay off the added cost of the daylight fixtures would be $(4000 - 500)/(480 + 120 - 90)$ or less than 7 years.

Conclusion

A relatively new field of daylighting design is open to illuminating engineers. Using methods similar to that used for artificial lighting design, interiors can be well lighted by daylight throughout the day. It is hoped that the architect and engineer will combine talents in making interiors pleasant and cheerful to work and see in, under daylight illumination.

The author wishes to thank Mr. Irving Cohen for his great help and assistance in the preparation of this paper. The research which led to the development of the domes discussed here and the subsequent daylighting studies were sponsored by the Wasco Flashing Company, Cambridge, Mass.

References

1. Moon, Parry: *The Scientific Basis of Illuminating Engineering*, McGraw Hill Book Company, Inc., 1936.
2. Moon, Parry, and Spencer, Domina Eberle: *Lighting Design*, Addison-Wesley Press, Inc., 1948.

DISCUSSION

J. W. GRIFFITH*: The curve in Fig. 2 is based on an equivalent sky-brightness of 1000 footlamberts. This is rather standard procedure for overcast daylighting but is of little value for clear sky conditions with sun on the plastic dome. If, in the example shown, we substitute a clear sky condition in which the sun may produce 10,000 footcandles on the dome, the brightness of the dome would be 3,360 footlamberts. I would like to know what type of control the author recommends when sun is on the dome.

It is rather difficult to determine whether the curves in Figs. 3, 4, 5, 6 and 7 are based on actual measurements or whether they are calculated curves. In either case, I would like to know the amount of illumination on the horizontal plane, the amount of illumination on the vertical side wall window, and what amount of this side wall illumination came from the ground. If the curves are based on calculations, I would particularly like to know what technique was used to predict the maintained illumination of the side wall window and what ground reflectance was assumed outside the window.

R. W. MCKINLEY*: For comparison with other data published on the basis of daylight illumination on the horizontal, could Mr. Greene tell us what the approximate daylight on the horizontal would be related to his sky-brightness of 1000 footlamberts?

Because skylights are frequently considered when ceiling heights are relatively low, could he give some curves for distribution assuming ceiling height 6 feet above the working plane?

It would be interesting to see how actual field measurements compare with these calculated performance curves.

What is the approximate installed cost per square foot of the luminous ceiling skylight combination shown in Fig. 15? What would he suggest using as the utilization coefficient for the electric lighting component of this system?

R. A. BOYD**: In the introduction to this paper Mr. Greene has referred to a uniform sky that produces a horizontal surface illumination of 1000 lumens per square foot and a vertical surface illumination of 500 lumens per square foot; the implication being that this is an overcast sky.

The data published by H. H. Kimball in the *U. S. Weather Review* and the data collected by the Daylighting Laboratory indicate very definitely that the brightness of an overcast sky is not uniform. These data indicate that the ratio of horizontal to vertical surface illumination, neglecting ground reflections, is about 2.5 to 1; also, the illumination of a vertical surface is independent of exposure. This is due to the fact that the brightness of a segment of an overcast sky is practically independent of its azimuth position but is a function of its altitude position. This altitude relationship is quite well represented by $B_\theta = B_o(0.4 + 0.6 \sin \theta)$, where B_o is the zenith brightness in footlamberts and B_θ the brightness at any position having an altitude θ. Calculations of horizontal and vertical surface illuminations using this altitude relationship show that H.S.I. $= 0.80\ B_o$ and V.S.I. $= 0.33\ B_o$, respectively; thus, the ratio of H.S.I. to V.S.I. is 2.42 to 1.

These characteristics of an overcast sky appear quite logical. As the sky becomes more and more cloudy the entire sky vault becomes a diffuser so that the location of the sun is obscured, consequently all vertical surfaces receive the same amount of light and the variation in the thickness of the atmosphere causes the sky brightness to be a maximum at the zenith and a minimum at the horizon. On the basis of these data, it would appear that a uniform sky is a rarity whereas an overcast sky is quite common.

E. W. CONOVER†: I will take very little time to discuss this paper as it appears to be well thought out and presented.

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*Pittsburgh Corning Corp., Pittsburgh, Pa.
**Daylighting Laboratory, University of Michigan, Ann Arbor, Mich.
†Detroit Steel Products, Detroit, Mich.

My main comment is that all of the results given in the form of curves are based solely on calculations using the interreflection method. It would be much more convincing to architects and engineers if a few field or laboratory tests had been conducted to show how closely they came to the theoretical curves.

It is stated that all of the graphs were for the average distribution across the room. It would be interesting to know the high and low values for the positions directly under the dome and midway between domes.

DOMINA EBERLE SPENCER*: The methods of calculating both the direct light from the domes and the helios distribution with interflections are examples of good engineering practice. A possible defect of the paper is a tenacious emphasis of *quantity* of light at the expense of *quality* of lighting. The spacing recommendations are set up to give a uniform illumination distribution over the principal surface. The fact that the resulting spacing of small bright domes will give both direct and reflected glare is not mentioned.

Dependence on daylighting for schoolrooms and other areas in which work is to be done can be justified only if the visual environment is as well designed as can be obtained with the best artificial lighting systems. The same criteria should apply in both cases. But from Mr. Greene's own example, we find adaptation helios ratios of over 300 between a typical task and the domes and ratios of even more between the ceiling and the dome. Such a helios distribution may perhaps, be considered satisfactory in a factory warehouse. But it is not satisfactory for a classroom, office, or factory work space. The 3:1 adaptation helios ratio is exceeded. There will be many lines of sight for which visual conditions are highly unsatisfactory.

In order to reduce the high ratios, it is necessary to extend the luminous areas over essentially the entire ceiling. And, if the entire ceiling must be covered with bubbles, the economic picture changes drastically.

In Mr. Greene's economic example the cost of the domes is $4000 for 400 ft.^{2} or about $10 per square foot. In his example he covers about 10 per cent of the ceiling area with domes and estimates that the time required to pay for the bubbles out of savings in the electric bill is 7 years. If the entire ceiling is covered with domes it will be paid for in 70 years! Does the manufacturer guarantee the product against solarization for 70 years?

The bubbles also have a hidden cost not mentioned in Mr. Greene's example. They will reduce the coefficient of utilization of the artificial lighting system. If this is taken into account, we may not have our room full of bubbles paid for till 2054!

It is hard to see how a daylighting system at an initial cost of $10 per square foot can compete with standard luminous ceilings at $2 or $3 per square foot even when the savings in the electric bill are considered. If comparable quality is to be provided by a daylighting and by an artificial lighting system, the artificial lighting system appears to be less expensive.

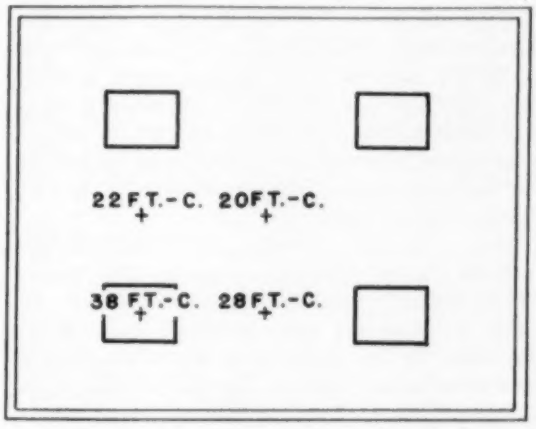
BERNARD F. GREENE†: As noted by Mr. Griffith, some control is necessary for the case where direct sunlight impinges on the dome. When using plastic domes, control is obtained by mounting the dome in a well. The usual depth of the well is such that direct shielding of the dome is obtained in a manner similar to use of louver devices. It is also possible to use ceiling domes (Fig. 13) or louvers at the finished ceiling line to obtain additional shielding.

*University of Connecticut, Storrs, Conn.
†Author.

The curves of illumination from side wall windows were calculated based on an overcast sky brightness of 1000 ft-L and a ground reflection of 15 per cent. The vertical illumination is taken as 570 footcandles.

With regard to the question of Mr. McKinley, we should like to state that there will be a small difference in the distribution curve when using a ceiling height of 6 feet above the working plane. The distribution for this arrangement would have a slightly higher peak value and narrower distribution. Considering the scale on the drawings, the difference would not be significant.

The calculated values given in the paper have been checked by field measurements. For example, in a room 21 x 27 feet with a 10-foot 6-inch ceiling height and no side wall windows; four 3 x 4 skylight domes together with ceiling domes were installed. The wall reflectance was 45 per cent and the ceiling reflectance 70 per cent. The measured horizontal illumination outside was 1200 footcandles while the illumination in the room was as shown below. The calculated value is 25 footcandles average.



The coefficient of utilization would be lowered somewhat for the artificial lighting equipment used in the room when plastic domes are used. Th exact amount would depend upon the room dimensions, area of domes used, reflectance of ceiling and distribution of the luminaires. For a 30 ft-c installation in a room without sidewall windows the amount would be between 5 and 15 per cent. The higher figure is for a totally indirect luminaire.

We are very much in agreement with Miss Spencer that quality of illumination should not be sacrificed for quantity. The use of plastic domes will give an installation of higher quality than most other types of daylight installations and one that usually exceeds in quality that of a general artificial lighting system.

Plastic domes mounted in a suitable well will be shielded from most room positions and the brightness of the plastic will rarely exceed that of a fluorescent lamp. The brightness ratios that we have found in a typical room using the plastic domes are very much less than those given by Miss Spencer.

A ceiling that is entirely covered with plastic domes would make for a very nice arrangement. The illumination level would be of the order of several hundred ft-c, a level which admittedly very few can afford to install either by daylighting or artificial lighting systems.

Many architects have found that daylight installations have several advantages other than that of economics; the primary ones being aesthetic and psychological.

Interflectance Factors for Additional Combinations of Reflectance

By WENTWORTH M. POTTER
CHARLOTTE WELLNER

FOR MANY years coefficients of utilization for interior lighting have been presented in abridged tables of six or eight columns. Each column represented one combination of ceiling, wall and floor reflectance. The latter, though unstated, was 0.14, the principal value employed in the measurements made by Harrison and Anderson.[1,2] As for ceiling and walls, reflectance values of 0.75, 0.50, 0.30, and 0.50, 0.30, 0.10, respectively, have been selected. Many are not aware that the underlying tables[2] presented utilization data for ceiling and wall reflectances from zero to 0.80 in steps of 0.10 for both surfaces.

Today expanded reference tables are needed. They should recognize, for example, that paints with initial reflectances as high as 0.80-0.85, or even higher, are often employed. Likewise, readily available data for low reflectances would facilitate a more accurate and realistic appraisal of some plans and installations. Such expanded tables, which might include as many as 15 columns for each of two floor reflectances, would usually appear in reference material. An example (including a few room proportions only) is found in Table VI of the 1953 I.E.S. Conference Paper "Measured Utilization Factors."[3] Naturally such tables would often be abridged appropriately, and proposals for guiding such abridgements have been considered by the I.E.S. Committee on Lighting Design practice.

We believe that in any case a wide range of conditions should be covered. Recent measurements of utilization have included reflectance values from 0.05 to 0.80 or more. We have also desired mathematically-derived interflectance (f) factors[4] for high and low reflectance values to facilitate calculations of utilization and comparisons with test data. Accordingly, we have evaluated the Moon and Spencer equations (*e.g.*, Fig. 1) to obtain the "f" factors for ceiling reflectances of 0.90, 0.30, and 0.00. With interpolated values for ceiling reflectances 0.85 and 0.10, these are presented in Table I. They extend the range of similar tables published elsewhere.[5,6,7,8]

Interflectance values for ceiling reflectance 0.90 and a range of combinations of wall and floor reflectances are given in Table II.

AUTHORS: Application Engineering Department, Lamp Division of General Electric Co., Cleveland, Ohio.

$$\text{Interflectance } f_1 = \left(\frac{\text{Lumens to Work Plane}}{\text{Lumens to Wall Surface}}\right)$$

$$f_1 = \frac{\rho_2}{4k_r(1-\rho_1)} + \left\{\frac{\rho_2}{4k_r(1-\rho_1)\left(\left[2(1+\rho_1\rho_3)-\rho_1(1+\rho_3)(1+\rho_3)\right]\sinh\left(2k_r\sqrt{1-\rho_1}\right)+2\sqrt{1-\rho_1}\,(1-\rho_3)\rho_3\cosh\left(2k_r\sqrt{1-\rho_1}\right)\right)}\right\} \times$$

$$\left\{\left[(1-\rho_1)\left[2-\rho_1(1+\rho_3)\right]\cosh\left(2k_r\sqrt{1-\rho_1}\right)+2\sqrt{1-\rho_1}\,(1-\rho_3)\sinh\left(2k_r\sqrt{1-\rho_1}\right)+(1-\rho_1)\left[2\rho_3-\rho_1(1+\rho_3)\right]\right]\sinh\left(2k_r\sqrt{1-\rho_1}\frac{h'}{h}\right)-\right.$$

$$\left.\left[(1-\rho_1)\left[2-\rho_1(1+\rho_3)\right]\sinh\left(2k_r\sqrt{1-\rho_1}\right)+2\sqrt{1-\rho_1}\,(1-\rho_3)\cosh\left(2k_r\sqrt{1-\rho_1}\right)+2\rho_3\sqrt{1-\rho_1}\,(1-\rho_3)\right]\cosh\left(2k_r\sqrt{1-\rho_1}\frac{h'}{h}\right)\right\}$$

Reflectance Values:			
Ceiling	ρ_2	Room Height	h
Walls	ρ_1	Ceiling to Work Plane	h'
Floor	ρ_3	Room Proportion	k_r

TABLE I.—Values for Ceiling Reflectances 0.90, 0.30, and 0.00 Were Derived from the Equations; For 0.85 and 0.10 Interpolated Values Are Given.

Interflectance (f_1) Factors for Wall

Ceil. Refl.	0.90			0.85			0.30			0.10			0.00		
Wall Refl.	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
k_r	Floor Reflectance — 0.10														
0															
.1	.4171	.2397	.0768	.403	.232	.079	.2560	.1492	.0484	.208	.122	.040	.1840	.1078	.0352
.2	.3787	.2101	.0652	.366	.204	.063	.2402	.1367	.0434	.199	.114	.036	.1790	.1030	.0330
.3	.3449	.1857	.0561	.334	.181	.055	.2261	.1259	.0391	.191	.107	.034	.1742	.0985	.0310
.4	.3149	.1652	.0489	.306	.161	.048	.2134	.1164	.0356	.184	.101	.031	.1693	.0940	.0292
.5	.2885	.1480	.0431	.280	.144	.042	.2017	.1081	.0326	.176	.096	.029	.1643	.0898	.0275
.6	.2651	.1335	.0383	.258	.130	.038	.1910	.1008	.0300	.170	.091	.027	.1592	.0857	.0259
.7	.2446	.1211	.0343	.239	.119	.034	.1813	.0942	.0277	.163	.086	.026	.1542	.0818	.0244
1.0	.1958	.0935	.0259	.192	.092	.0256	.1564	.0784	.0224	.145	.074	.021	.1396	.0714	.0207
1.4	.1524	.0707	.0192	.150	.070	.019	.1311	.0634	.0177	.125	.061	.017	.1221	.0600	.0169
2.0	.1129	.0511	.0137	.113	.051	.0136	.1042	.0485	.0132	.102	.048	.013	.1005	.0474	.0130
	Floor Reflectance — 0.30														
0															
.1	.5068	.2870	.0906	.483	.274	.087	.2736	.1585	.0513	.213	.124	.040	.1852	.1082	.0352
.2	.4426	.2401	.0730	.424	.231	.070	.2549	.1436	.0451	.204	.116	.037	.1816	.1040	.0331
.3	.3912	.2052	.0608	.376	.198	.059	.2384	.1310	.0403	.196	.109	.034	.1775	.0996	.0311
.4	.3491	.1783	.0518	.337	.173	.050	.2237	.1204	.0364	.190	.103	.032	.1730	.0952	.0293
.5	.3141	.1571	.0449	.304	.153	.044	.2105	.1112	.0331	.182	.097	.029	.1682	.0909	.0276
.6	.2846	.1399	.0395	.277	.137	.039	.1986	.1032	.0303	.174	.092	.027	1631	.0868	.0260
.7	.2598	.1257	.0351	.253	.123	.034	.1879	.0962	.0279	.168	.087	.026	.1581	.0829	.0245
1.0	.2037	.0956	.0261	.200	.094	.026	.1610	.0795	.0225	.148	.074	.021	.1430	.0722	.0208
1.4	.1564	.0716	.0193	.155	.071	.019	.1341	.0641	.0177	.128	.062	.017	.1248	.0606	.0170
2.0	.1148	.0515	.0137	.114	.0513	.0136	.1060	.0489	.0132	.104	.048	.013	.1022	.0477	.0130

Interflectance (f_2) Factors for Ceiling

Ceil. Refl.	0.90			0.85			0.30			0.10			0.00		
Wall Refl.	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
k_r	Floor Reflectance — 0.10														
0	.9891	.9891	.9891	.929	.929	.929	.3093	.3093	.3093	.101	.101	.101			
.1	.9032	.8698	.8388	.848	.818	.789	.2790	.2726	.2664	.091	.088	.088			
.2	.8222	.7657	.7168	.771	.720	.675	.2516	.2403	.2301	.082	.078	.076			
.3	.7465	.6743	.6155	.699	.633	.580	.2268	.2119	.1989	.074	.068	.065			
.4	.6762	.5941	.5301	.635	.558	.500	.2044	.1868	.1721	.066	.059	.056			
.5	.6116	.5236	.4576	.572	.492	.432	.1840	.1647	.1491	.060	.052	.049		0	
.6	.5524	.4617	.3956	.516	.430	.375	.1657	.1453	.1292	.054	.046	.042			
.7	.4984	.4069	.3424	.467	.383	.323	.1492	.1281	.1119	.048	.041	.037			
1.0	.3649	.2790	.2226	.340	.263	.210	.1088	.0879	.0730	.035	.028	.024			
1.4	.2397	.1690	.1259	.225	.157	.118	.0713	.0532	.0412	.023	.017	.013			
2.0	.1272	.0796	.0536	.119	.075	.050	.0378	.0250	.0176	.012	.008	.006			
	Floor Reflectance — 0.30														
0	1.2328	1.2328	1.2328	1.1397	1.1397	1.1397	.3297	.3297	.3297	.103	.103	.103			
.1	1.0721	1.0178	.9685	.994	.948	.903	.2947	.2863	.2785	.093	.091	.089			
.2	.9407	.8575	.7888	.868	.802	.738	.2637	.2498	.2373	.084	.080	.077			
.3	.8303	.7328	.6567	.773	.686	.617	.2363	.2185	.2033	.075	.070	.066			
.4	.7364	.6321	.5543	.686	.592	.521	.2118	.1915	.1749	.068	.062	.057			
.5	.6550	.5487	.4721	.611	.515	.445	.1900	.1681	.1508	.061	.055	.050		0	
.6	.5844	.4784	.4044	.544	.450	.382	.1705	.1478	.1303	.055	.048	.043			
.7	.5223	.4185	.3477	.487	.393	.328	.1530	.1300	.1127	.049	.042	.037			
1.0	.3753	.2832	.2240	.352	.266	.211	.1108	.0887	.0732	.036	.092	.024			
1.4	.2437	.1701	.1261	.238	.160	.119	.0723	.0536	.0414	.023	.018	.014			
2.0	.1284	.0798	.0536	.120	.075	.051	.0382	.0253	.0176	.012	.008	.006			

TABLE I continued on the following page

← **Figure 1. Equation for f_1 (walls); This is equation (22), Reference 4, multiplied by $\rho_1/4k_r$. Corrections supplied by the authors of this reference are incorporated. Values of f_2 and f_3 in the tables are derived from equations (27) and (32) of the same reference.**

Interflectance (f_3) Factors for Floor

Ceil. Refl.	0.90			0.85			0.30			0.10			0.00		
Wall Refl.	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
h_r	Floor Reflectance — 0.10														
0	1.0989	1.0989	1.0989	1.093	1.093	1.093	1.0309	1.0309	1.0309	1.010	1.010	1.010	1.0000	1.0000	1.0000
.1	1.0814	1.0755	1.0701	1.077	1.071	1.066	1.0274	1.0250	1.0227	1.011	1.010	1.008	1.0033	1.0019	1.0006
.2	1.0673	1.0581	1.0501	1.063	1.055	1.047	1.0245	1.0205	1.0168	1.012	1.009	1.006	1.0057	1.0033	1.0010
.3	1.0559	1.0450	1.0362	1.053	1.043	1.034	1.0222	1.0170	1.0126	1.012	1.008	1.005	1.0074	1.0042	1.0013
.4	1.0468	1.0352	1.0263	1.044	1.033	1.025	1.0202	1.0144	1.0096	1.012	1.008	1.004	1.0087	1.0048	1.0015
.5	1.0395	1.0279	1.0193	1.038	1.026	1.018	1.0186	1.0123	1.0074	1.013	1.008	1.004	1.0096	1.0052	1.0016
.6	1.0336	1.0224	1.0143	1.032	1.021	1.013	1.0172	1.0108	1.0058	1.012	1.007	1.003	1.0102	1.0054	1.0016
.7	1.0289	1.0182	1.0107	1.028	1.017	1.010	1.0160	1.0095	1.0046	1.012	1.007	1.002	1.0106	1.0055	1.0016
1.0	1.0196	1.0107	1.0049	1.019	1.010	1.005	1.0134	1.0071	1.0026	1.012	1.006	1.002	1.0108	1.0054	1.0015
1.4	1.0134	1.0065	1.0022	1.014	1.006	1.002	1.0111	1.0054	1.0016	1.010	1.005	1.001	1.0101	1.0048	1.0013
2.0	1.0092	1.0041	1.0011	1.009	1.004	1.0011	1.0087	1.0039	1.0011	1.009	1.004	1.001	1.0085	1.0039	1.0010
	Floor Reflectance — 0.30														
0	1.3698	1.3698	1.3698	1.342	1.342	1.342	1.0989	1.0989	1.0989	1.031	1.031	1.031	1.0000	1.0000	1.0000
.1	1.2906	1.2654	1.2428	1.270	1.248	1.226	1.0870	1.0788	1.0711	1.034	1.029	1.024	1.0098	1.0058	1.0019
.2	1.2320	1.1956	1.1656	1.217	1.183	1.155	1.0775	1.0640	1.0520	1.036	1.027	1.019	1.0172	1.0098	1.0031
.3	1.1878	1.1475	1.1160	1.176	1.139	1.109	1.0698	1.0529	1.0386	1.038	1.026	1.015	1.0227	1.0127	1.0040
.4	1.1541	1.1130	1.0827	1.146	1.107	1.078	1.0634	1.0445	1.0292	1.038	1.024	1.013	1.0268	1.0146	1.0045
.5	1.1281	1.0882	1.0599	1.122	1.084	1.057	1.0582	1.0380	1.0224	1.039	1.023	1.011	1.0296	1.0158	1.0048
.6	1.1079	1.0700	1.0440	1.099	1.066	1.042	1.0538	1.0331	1.0175	1.039	1.022	1.009	1.0315	1.0166	1.0049
.7	1.0920	1.0565	1.0328	1.088	1.054	1.031	1.0501	1.0292	1.0140	1.038	1.021	1.008	1.0327	1.0169	1.0049
1.0	1.0615	1.0328	1.0148	1.060	1.032	1.014	1.0418	1.0217	1.0080	1.036	1.018	1.006	1.0335	1.0166	1.0047
1.4	1.0417	1.0198	1.0067	1.041	1.019	1.0066	1.0344	1.0164	1.0049	1.032	1.015	1.004	1.0314	1.0148	1.0040
2.0	1.0287	1.0126	1.0034	1.028	1.0126	1.0034	1.0271	1.0121	1.0032	1.027	1.012	1.003	1.0264	1.0118	1.0030

TABLE II.—Interflectance Factors for Ceiling Reflectance 0.90.

Interflectance (f_1) Factors for Walls
Ceiling Reflectance 0.90

	Floor Reflectance — 0.00 Wall Reflectance							Floor Reflecance — 0.30 Wall Reflectance					
h_r	0.80	0.70	0.50	0.30	0.10	0.00	h_r	0.80	0.70	0.50	0.30	0.10	0.00
0	———	———	———	———	———	———	0	———	———	———	———	———	———
.1	.6470	.5550	.3821	.2209	.0711	.0000	.1	.8898	.7537	.5068	.2870	.0906	.0000
.2	.6316	.5313	.3525	.1974	.0618	.0000	.2	.8429	.6926	.4426	.2401	.0730	.0000
.3	.6144	.5072	.3252	.1770	.0552	.0000	.3	.7976	.6391	.3912	.2052	.0608	.0000
.4	.5964	.4829	.3000	.1591	.0476	.0000	.4	.7550	.5915	.3491	.1783	.0518	.0000
.5	.5778	.4593	.2771	.1438	.0422	.0000	.5	.7158	.5489	.3141	.1571	.0449	.0000
.6	.5587	.4364	.2563	.1305	.0378	.0000	.6	.6794	.5111	.2846	.1399	.0395	.0000
.7	.5399	.4146	.2376	.1189	.0340	.0000	.7	.6453	.4770	.2598	.1257	.0351	.0000
1.0	.4849	.3560	.1922	.0926	.0257	.0000	1.0	.5573	.3946	.2037	.0956	.0261	.0000
1.4	.4201	.2944	.1505	.0702	.0192	.0000	1.4	.4668	.3170	.1564	.0716	.0193	.0000
2.0	.3431	.2299	.1119	.0509	.0136	.0000	2.0	.3705	.2422	.1148	.0515	.0137	.0000
	Floor Reflectance — 0.15 Wall Reflectance							Floor Reflectance — 0.45 Wall Reflectance					
h_r	0.80	0.70	0.50	0.30	0.10	0.00	h_r	0.80	0.70	0.50	0.30	0.10	0.00
0	———	———	———	———	———	———	0	———	———	———	———	———	———
.1	.7488	.6416	.4365	.2503	.0798	.0000	.1	1.0832	.9093	.6004	.3316	.1041	.0000
.2	.7232	.6026	.3931	.2170	.0670	.0000	.2	1.0037	.8126	.5048	.2679	.0801	.0000
.3	.6947	.5662	.3555	.1903	.0572	.0000	.3	.9320	.7322	.4340	.2225	.0647	.0000
.4	.6672	.5320	.3229	.1684	.0496	.0000	.4	.8686	.6647	.3795	.1894	.0541	.0000
.5	.6396	.5002	.2945	.1502	.0435	.0000	.5	.8120	.6074	.3363	.1646	.0463	.0000
.6	.6132	.4709	.2697	.1350	.0386	.0000	.6	.7612	.5586	.3013	.1451	.0404	.0000
.7	.5879	.4435	.2482	.1222	.0345	.0000	.7	.7158	.5160	.2725	.1294	.0357	.0000
1.0	.5182	.3742	.1978	.0940	.0259	.0000	1.0	.6037	.4178	.2101	.0972	.0263	.0000
1.4	.4419	.3051	.1533	.0709	.0192	.0000	1.4	.4958	.3303	.1596	.0723	.0194	.0000
2.0	.3560	.2357	.1133	.0512	.0137	.0000	2.0	.3870	.2493	.1164	.0518	.0137	.0000

References and Footnotes

1. Harrison, Ward, and Anderson, Earl A.: "Illumination Efficiencies as Determined in an Experimental Room," *Transactions* of the Illuminating Engineering Society, Vol. XI, p. 67 (1916).
2. Harrison, Ward, and Anderson, Earl A.: "Coefficients of Utilization," *Transactions* of the Illuminating Engineering Society, Vol. XV, p. 97 (1920).
3. Potter, Wentworth M., and Russell, Anson H.: "Measured Utilization Factors," ILLUMINATING ENGINEERING, Vol. XLIX, No. 3, p. 137 (March 1954).
4. Moon, Parry, and Spencer, Domina Eberle: "Light Distributions in Rooms," *Journal of the Franklin Institute*, Vol. 242, No. 2, p. 111 (August 1946). (Interflectance or "*f*" factors are the fractions of flux initially incident on ceiling, walls, and floor which reach the reference- or work-plane directly and by interreflection. The calculations assume uniform initial illumination of room surfaces and perfect diffusion of those surfaces.)
5. Moon ,Parry, and Spencer, Domina Eberle: "Lighting Design by the Interflection Method," *Journal of the Franklin Institute*, Vol. 242, No. 6, p. 465 (December 1946). Corrections for certain pub-

Interflectance (f_2) Factors for Ceiling
Ceiling Reflectance 0.90

	Floor Reflectance — 0.00 Wall Reflectance							Floor Reflecance — 0.30 Wall Reflectance					
k_r	0.80	0.70	0.50	0.30	0.10	0.00	k_r	0.80	0.70	0.50	0.30	0.10	0.00
0	.9000	.9000	.9000	.9000	.9000	.9000	0	1.2328	1.2328	1.2328	1.2328	1.2328	1.2328
.1	.8811	.8662	.8375	.8112	.7863	.7747	.1	1.1676	1.1338	1.0721	1.0178	.9685	.9452
.2	.8582	.8282	.7740	.7269	.6856	.6639	.2	1.1039	1.0432	.9407	.8575	.7888	.7557
.3	.8318	.7869	.7109	.6485	.5966	.5739	.3	1.0421	.9580	.8303	.7328	.6567	.6248
.4	.8024	.7442	.6501	.5770	.5188	.4940	.4	.9826	.8835	.7364	.6321	.5543	.5224
.5	.7713	.7006	.5920	.5121	.4508	.4251	.5	.9253	.8132	.6550	.5487	.4721	.4413
.6	.7385	.6574	.5379	.4539	.3914	.3659	.6	.8704	.7487	.5844	.4784	.4044	.3752
.7	.7052	.6152	.4872	.4017	.3398	.3149	.7	.8181	.6892	.5223	.4185	.3477	.3203
1.0	.6053	.4969	.3599	.2772	.2221	.2009	1.0	.6779	.5382	.3753	.2832	.2240	.2018
1.4	.4814	.3673	.2379	.1684	.1257	.1102	1.4	.5218	.3872	.2437	.1701	.1261	.1102
2.0	.3344	.2286	.1265	.0795	.0535	.0450	2.0	.3526	.2363	.1284	.0798	.0536	.0450
	Floor Reflectance — 0.15 Wall Reflectance							Floor Reflectance — 0.45 Wall Reflectance					
k_r	0.80	0.70	0.50	0.30	0.10	0.00	k_r	0.80	0.70	0.50	0.30	0.10	0.00
0	1.0404	1.0404	1.0404	1.0404	1.0404	1.0404	0	1.5125	1.5125	1.5125	1.5125	1.5125	1.5125
.1	1.0040	.9817	.9403	.9025	.8679	.8517	.1	1.3967	1.3431	1.2477	1.1662	1.0953	1.0633
.2	.9651	.9227	.8490	.7867	.7336	.7070	.2	1.2921	1.2016	1.0553	.9428	.8533	.8117
.3	.9241	.8641	.7657	.6879	.6253	.5982	.3	1.1975	1.0814	.9077	.7841	.6916	.6537
.4	.8825	.8073	.6901	.6031	.5360	.5079	.4	1.1115	.9776	.7898	.6640	.5740	.5379
.5	.8403	.7520	.6217	.5296	.4612	.4332	.5	1.0328	.8869	.6927	.5692	.4835	.4498
.6	.7979	.6996	.5600	.4658	.3978	.3706	.6	.9602	.8069	.6115	.4919	.4111	.3798
.7	.7564	.6495	.5041	.4098	.3436	.3175	.7	.8937	.7357	.5421	.4275	.3517	.3228
1.0	.6383	.5162	.3674	.2802	.2229	.2012	1.0	.7232	.5629	.3838	.2862	.2251	.2024
1.4	.5002	.3766	.2407	.1693	.1259	.1102	1.4	.5471	.3990	.2469	.1712	.1264	.1101
2.0	.3427	.2322	.1274	.0797	.0536	.0450	2.0	.3639	.2407	.1296	.0799	.0537	.0450

Interflectance (f_2) Factors for Floor
Ceiling Reflectance 0.90

	Floor Reflectance — 0.00 Wall Reflectance							Floor Reflecance — 0.30 Wall Reflectance					
k_r	0.80	0.70	0.50	0.30	0.10	0.00	k_r	0.80	0.70	0.50	0.30	0.10	0.00
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0	1.3698	1.3698	1.3698	1.3698	1.3698	1.3698
.1							.1	1.3348	1.3191	1.2906	1.2654	1.2428	1.2321
.2							.2	1.3038	1.2770	1.2320	1.1956	1.1656	1.1526
.3							.3	1.2764	1.2420	1.1878	1.1474	1.1160	1.1028
.4							.4	1.2523	1.2127	1.1541	1.1130	1.0827	1.0704
.5							.5	1.2311	1.1882	1.1281	1.0882	1.0599	1.0487
.6							.6	1.2124	1.1677	1.1079	1.0700	1.0440	1.0339
.7							.7	1.1960	1.1504	1.0920	1.0565	1.0328	1.0237
1.0							1.0	1.1575	1.1130	1.0615	1.0328	1.0148	1.0082
1.4							1.4	1.1237	1.0840	1.0417	1.0198	1.0067	1.0020
2.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	2.0	1.0943	1.0614	1.0287	1.0126	1.0034	1.0002
	Floor Reflectance — 0.15 Wall Reflectance							Floor Reflectance — 0.45 Wall Reflectance					
k_r	0.80	0.70	0.50	0.30	0.10	0.00	k_r	0.80	0.70	0.50	0.30	0.10	0.00
0	1.1561	1.1561	1.1561	1.1561	1.1561	1.1561	0	1.6806	1.6806	1.6806	1.6806	1.6806	1.6806
.1	1.1435	1.1378	1.1272	1.1176	1.1087	1.1046	.1	1.6025	1.5685	1.5082	1.4567	1.4120	1.3917
.2	1.1320	1.1219	1.1043	1.0896	1.0770	1.0714	.2	1.5364	1.4810	1.3920	1.3233	1.2690	1.2458
.3	1.1216	1.1081	1.0862	1.0687	1.0552	1.0492	.3	1.4806	1.4119	1.3096	1.2372	1.1834	1.1614
.4	1.1121	1.0962	1.0718	1.0537	1.0400	1.0342	.4	1.4329	1.3564	1.2496	1.1789	1.1287	1.1088
.5	1.1035	1.0860	1.0603	1.0424	1.0292	1.0239	.5	1.3921	1.3115	1.2049	1.1380	1.0922	1.0744
.6	1.0959	1.0773	1.0512	1.0339	1.0216	1.0167	.6	1.3571	1.2748	1.1710	1.1085	1.0672	1.0514
.7	1.0890	1.0698	1.0440	1.0275	1.0161	1.0117	.7	1.3270	1.2446	1.1448	1.0870	1.0498	1.0358
1.0	1.0725	1.0531	1.0297	1.0161	1.0074	1.0041	1.0	1.2585	1.1810	1.0956	1.0501	1.0224	1.0123
1.4	1.0575	1.0399	1.0202	1.0098	1.0033	1.0010	1.4	1.2007	1.1333	1.0644	1.0302	1.0101	1.0030
2.0	1.0441	1.0293	1.0140	1.0062	1.0017	1.0001	2.0	1.1518	1.0969	1.0442	1.0192	1.0052	1.0004

lished values of f_1 (Wall Lighting), Table IX, p. 492, should be noted:

Reflectance Combinations				*Published*	*Corrected*
Ceiling	*Wall*	*Floor*	k_r	*Value*	*Value*
0.80	0.50	0.10	1.0	.1811	.1886
0.80	0.50	0.30	0.1	.4427	.4611
0.80	0.50	0.30	1.0	.1880	.1958
0.70	0.50	0.10	1.0	.1744	.1815
0.70	0.50	0.30	0.1	.4019	.4186
0.70	0.50	0.30	1.0	.1808	.1882
0.50	0.50	0.10	1.0	.1618	.1683
0.50	0.50	0.30	1.0	.1671	.1740

Also two values of f_0, Table I, page 488:

0.80	0.50	0.10	1.0	.3158	.3178
0.80	0.30	0.10	1.0	.2478	.2458

(The above apply also for the corresponding tables in References 6 and 7.)

6. "Brightness Distribution in Rooms," Report No. 4, Committee on Standards of Quality and Quantity for Interior Illumination, ILLUMINATING ENGINEERING, Vol. XLII, p. 180 (1947).
7. Coradeschi, R. A., and Innis, L. E.: "An Application of the Interflection Theory to Commercial Practice," ILLUMINATING ENGINEERING, Vol. XLIII, No. 9, p. 949 (1948).
8. Lee, James S. Y.: "Interflection Tables for Rooms with Floors of High Reflectance," *Journal of the Franklin Institute*, Vol. 250, p. 409 (1950).

Some Observations of Fluorescent Street Lighting Here and Abroad

Discussion of paper by PHILIP H. HOUSER

(Published October 1953 issue of ILLUMINATING ENGINEERING)

D. W. ROWTEN*: I had not intended to comment on this paper, but after a more leisurely review of its implications, I feel compelled to point up some of its inconsistencies with accepted engineering reports.

(1) The author made reference, in his first paragraph to "Studies of Fluorescent Street Lighting," by the Research Subcommittee of the Illuminating Engineering Society's Street Lighting Committee, noting the portion recommending further study in the development of fluorescent lamp luminaires and the cooperation of all concerned in additional tests if more effective luminaires or sources are achieved. For a complete picture the reader should review the entire report. In so doing, he will find this statement in its second paragraph: "In these studies fluorescent street lighting, using lamps and luminaires to date, was found to be at a considerable economic disadvantage in comparison with modern filament lamp practices."

Certainly there have been improvements in the fluorescent lamp, but corresponding improvements have been made in other light sources which maintain the same economic disadvantage for the fluorescent system. Modern practice in this country supported by complete cost analysis similar to the summary shown in bar diagrams in Fig. D-1, points up the economic disadvantage of the fluorescent system as compared with other systems based on equal illumination values. It should be pointed out that the problem was carefully selected, to if possible show the fluorescent system to advantage. Had the lighting layout conformed with the preferred practice of locating the lighting units on the side of the roadway instead of in the center strip, the fluorescent system would have shown even less favorable by comparison.

(2) It is common knowledge that fluorescent street lighting has gained in popularity in England and Europe. However, Mr. Aldington in his address to the I.E.S. Street Lighting Committee in Chicago in 1952, attributed it to the necessity to conserve power and reduce power costs. They must pay as much as five to seven cents per kwh as compared to our average of one cent. Dr. Aldington further stated that the majority of their new lighting was mercury (in small lamp sizes). American tourists in England may get the impression that they are all out for fluorescent because it is new to the Americans and the British try to show them something that will be impressive.

(3) Mr. Houser raises the question "How much better is fluorescent street lighting?" I believe this implies a condition which has not yet been proven. There has been no proof that fluorescent street lighting is more comfortable, less glaring, than other light sources. Recently the members of the I.E.S. Street Lighting Committee were requested to evaluate from a visual inspection trip several lighting systems in Detroit, including filament and fluorescent systems. This group of competent observers were about equally divided as to their choice.

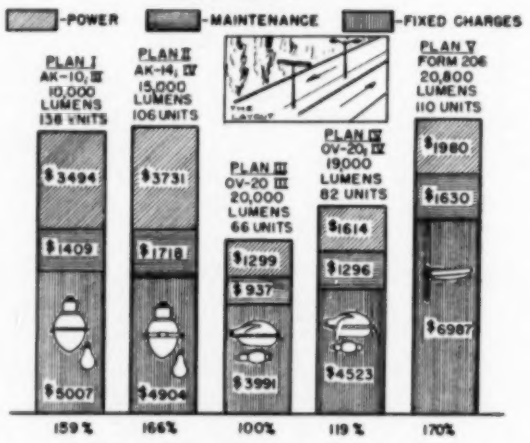
(4) Due to the long linear light source the brightness pattern afforded by fluorescent luminaires on a wet pavement may be expected to be very good where conditions permit seeing by silhouette. However, if we inspect our principal traffic and business streets during the rush hours, we will observe that the pavement is seldom in our line of vision. We cannot see the pavement for cars. This condition of congested traffic and limited pavement reflection areas has given emphasis to the practice of lighting for direct discernment. On heavily travelled streets we see principally by vertical illumination on the car or object ahead.

(5) Mr. Houser refers to a light distribution curve, and implies that it is ideal for lighting our typical business or traffic streets. It is obvious that with a very low value of maximum candlepower placed at 65 degrees this luminaire must be restricted to very close spacings in order to meet ASA requirements as to uniformity of illumination. This restriction makes it virtually impossible to design an installation employing such a luminaire to meet I.E.S. and ASA Standards of uniformity for illumination levels recommended in the Practice.

(6) Since the author makes no comparison of the modern mercury system to the filament or fluorescent system the cost analysis referred to above may be helpful in making a more complete comparison since it includes all the currently popular lighting systems.

(7) The author credits Mr. Ludovic Gaymard, Street Lighting Engineer for the City of Paris as favoring fluorescent lighting. In a recent visit to the United States Mr. Gaymard expressed considerable interest in the color corrected mercury light source and stated that it appeared likely that it would show an economic advantage over their fluorescent system on their wider streets and especially on roadways requiring illumination values comparable with our values.

A TYPICAL BUSINESS AREA LIGHTING LAYOUT
DESIGNED TO PROVIDE ONE FOOTCANDLE MAINTAINED
CA-5320-S



RELATIVE ANNUAL COST OF LIGHTING

Figure D-1.

*Westinghouse Electric Corp., Lighting Division, Cleveland, Ohio.

(8) Mr. Houser's references to the progress of fluorescent street lighting in Europe do not, I believe, permit any definite conclusions to be drawn as to a course to follow in America. The problems of power rates, traffic volume, traffic speeds, illumination values, roadway widths, areas involved, utilization, first cost, operation cost and others makes our problem very different from the problems in England and Europe.

(9) I am certain that we will continue to make improvements in all our light sources and luminaires and eventually the present economic disadvantages of the fluorescent system may be narrowed. Several fluorescent installations have already been made in this country. Others will be sold on the basis of novelty, newness, desire to be different from competitive communities and to some extent on the questionable claims of increased seeing comfort, but not at present on the basis of economic consideration alone. As Mr. Houser mentioned, street lighting must be paid for by the public. This emphasizes the necessity for public officials to completely analyze all systems and spend the taxpayers' money for the best interests of their communities, all factors considered.

(10) I still feel that the recommendations of the I.E.S. Committee in 1946 as quoted in Mr. Houser's paper are good. Manufacturers should study means of design to improve fluorescent lamps and luminaires and test installations should be made. The results of that work and those tests, all factors included, should then be presented in a clear factual manner. I do not wish to imply that I am prejudiced against fluorescent street lighting. On the contrary, I will recommend fluorescent street lighting for certain applications, but I hope only after a fair engineering study has been made and all the factors presented.

J. W. Steiner*: This paper makes interesting reading but fails, I believe, to make a single point. The implication that fluorescent street lighting is at least somewhat "better" may or may not be open to serious question. However, most certainly the quotation of a factor of "at least 1½ times" illumination to obtain equal visibility with mercury or incandescent *must* be questioned. Having included the statement that "Some observers have expressed the opinion . . . " that this factor might be applied, it is unfortunate that those observers were not named so that the reader might speculate as to whether they were *qualified* observers.

Again, the question of economics is raised, then left without answer but with the *implication* that operating and maintenance costs will be enough below those for incandescent and mercury installations to pay for added installation cost. This may be true in European countries where power is very high in cost, but our cost analyses here show the reverse to be true. And in this connection "low maintenance and servicing expense" is inferred by reference to European comments whereas it appears that with a typical American fluorescent street light just the reverse is true. Compared with mercury vapor, for example; there are four 6-foot lamps to handle and replace per 7500 hours of operation, instead of one 12-inch lamp per 6000 hours; there is a 6-foot cover and reflector to clean, instead of about an 18-inch; there is approximately 14 feet of gasketed joint length subject to possible distortion and bug or moisture leakage instead of about 4 feet.

To summarize, I fear the paper may leave the reader with an impression of certain definite facts and figures, whereas careful perusal discloses that the really intangible nature of the author's "observations" does not justify any factual conclusions.

H. S. Nonneman*: To judge a modern fluorescent street lighting system it must be seen in actual operation. For one year now we have had such a system in operation in the City of Oakwood, Ohio, a community contiguous to Dayton. We have observed the pleasing appearance of this system from the standpoint of low brightness, the color quality of the light source, the absence of practically all maintenance costs, and the most important thing — the effect on the average citizen from a psychological standpoint. We have had many people from all parts of the country who have viewed our downtown mercury lighting, which produces average levels from 3.5 to 5 ft-c, and compared it with the fluorescent installation in Oakwood, which produces a 1.7-ft-c level. In practically all cases, the average person expresses himself as believing the intensity of the fluorescent installation much higher than the downtown mercury lighting system.

In my estimation, the superiority of the fluorescent system over other types of lighting should be taken advantage of by all those interested in good street lighting, because it will receive instant acceptance by the layman, and will tend to advance street lighting progress in a relatively short time as did interior fluorescent lighting a number of years ago.

We have been visited by people from many parts of the United States and other parts of the world, and their reaction universally has been the same as that I have stated as my personal reaction.

Willard C. Brown**: Two years ago I had the opportunity of making some observations of fluorescent street lighting in England. Some of this was under very practical conditions, that is, driving in an automobile through the countryside and then, being in the state of mind of the ordinary motorist, coming upon the street lighting and judging it as one does under those circumstances.

Again, in this country I do a great deal of cross-country driving at night. Last year, for example, I drove at night more than 10,000 miles in such a manner. This gives me the opportunity of making a great many very practical observations of the qualities of street lighting in nearly every state in the Union, both filament and mercury.

My opinion is that fluorescent street lighting of the better types is far superior to what we are doing with mercury and filament street lighting. And that the situation is somewhat analogous to general interior lighting in the early days of the fluorescent lamp. Then, many spaces in offices, stores, schools, and factories were lighted with filament lamps in enclosing globes or white porcelain-enameled reflectors and similar devices. When the fluorescent lamp came along, many of us did not seem to appreciate how really superior the lighting result could be with it properly used. We thought instead of what a relatively low-wattage source it was; how many of them would be required for a given area; how much metal and plastic or glass would be necessary for proper control; and how the resultant cost, especially first cost, would be so very, very high that no one in his right mind would install fluorescent lighting in these kinds of places. How wrong we were! When the public found out how much better the results could be, in terms of better and more comfortable seeing, the then very high first

*Westinghouse Electric Corp., Lighting Division, Cleveland, Ohio.

*The Dayton Power and Light Co., Dayton, Ohio.
**Lamp Division, General Electric Co., Nela Park, Cleveland, Ohio.

TABLE D-I.—Initial Equipment and Partial Annual Operating Cost, per Mile
60-foot pavement; 1.25 ft-c fluorescent; 1.7 ft-c others.
(steel poles, underground series circuits)

Item	Lamp	F.206 Fluorescent 4, T-12 20,800 lumens	F.109 Filament 15,000 lumens	F.109 Mercury E-1 19,000 lumens	F.109 Color-Improved J-1 17,000 lumens	F.108 Filament 25,000 lumens
1. Number of units per mile		76	91	67	92	66
2. Equipment cost, *only*		$33,100	$28,700	$21,800	$29,400	$32,500
3. Annual lamp cost (35 percent off list)		414	405	684	1,158	560
4. Annual energy cost (1.5c kwh)		2,050	3,910	1,810	2,490	5,030
5. Total lamp & energy cost		2,464	4,315	2,494	3,648	5,590
6. Amortization (12 per cent of Item 2)		3,970	3,450	2,615	3,530	3,900
7. Final annual cost		6,434	7,765	5,109	7,178	9,490

NOTE: 1. No installation, maintenance nor other costs included.
2. Visibility from 1.25 ft-c of fluorescent judged equivalent to 1.7 ft-c from others.

cost seemed to be of less consequence, and we all remember how eagerly they took to fluorescent lighting.

I think the situation in street lighting is somewhat similar. So many of us are sitting back and saying, "Yes, it is good but it costs too much; the public will never pay for it." I think that if and when the public find out how really good it is, even to the extent of being, as I would put it, a completely different *kind* of lighting for our streets and highways . . . that they will demand it. Indeed, experiences abroad seem to bear out this conclusion.

So isn't it high time that we started putting in extensive "trial installations" of this new and better practice?

PHILIP H. HOUSER*: In these comments on Mr. Rowten's discussion, the numbered paragraphs correspond to those in his remarks.

(1) With reference to economics of fluorescent lighting Mr. Swetland, Manager of our Illuminating Laboratory, has prepared a summary which we feel more accurately depicts the cost of various systems. It will be noted that the assumptions made have been clearly defined and the items shown individually to facilitate checking and comparison with prevailing local costs. Note also the assumption of ⅓ improvement in visibility under fluorescent lighting at a given footcandle level, or 1.25 ft-c fluorescent equals 1.7 ft-c from smaller more concentrated sources. We sincerely believe that our observations and the observations of others have indicated that this footcandle visibility relationship is conservative. Mr. Nonneman's discussion is typical of supporting opinion that has been frequently expressed.

Mr. Swetland's analysis follows:

FLUORESCENT STREET LIGHTING COMPARATIVE COST STUDY
(TABLE D-I)

BASIC PREMISE — Fluorescent Luminaire Produces Better Visibility Than Other More Concentrated Filament and Mercury Luminaires, at an Equivalent Average Footcandle Level."

(A) A group of 180 municipal and utility street lighting authorities was polled on this question at a street lighting conference at Portsmouth, N. H., in May, 1953. The consensus of this group was that a 50 per cent improvement in visibility under fluorescent was quite realistic.

(B) In order to be conservative in this analysis, the comparison is based upon only ⅓ improvement or, 1.7 ft-c level for the other filament and mercury systems as an equivalent visibility basis to 1.25 ft-c from the fluorescent.

(C) Three reasons for this improved visibility:

1. *Lower luminaire brightness* — thus, less glare interference with visibility.

2. *Broader* areas of *pavement brightness*, especially under wet pavement conditions — thus, better silhouette visibility.

3. *Whiter color quality* of 'cool white' rapid-start lamps produces an improved over-all lighted appearance of a street — as compared to filament or mercury lamps.

(2) It appears that Mr. Rowten has misunderstood either Dr. Aldington or the writer — or perhaps both of us. The necessity to conserve power and reduce power costs in England and Europe has resulted in an increase in the use of *vapor* sources including sodium, mercury and fluorescent at the expense of filament. The preference for fluorescent over mercury and sodium is a result of fluorescent's greater comfort, improved visibility, better color, and popular *demand despite fluorescent's admittedly higher initial cost.* When evaluating Mr. Rowten's reference to Dr. Aldington's statement that the majority of their new lighting was mercury (in small lamp sizes) one must remember that this picture is colored by the small lamp residential street and secondary street lighting program which uses little if any fluorescent. The figures quoted in the original paper appear to give ample evidence of the increase in usage of fluorescent.

Mr. Rowten's reference to "American tourists in England" is not particularly applicable since we, unlike the average tourist, spent our evenings looking at street lighting installations and this, together with a total of nearly one thousand miles covered by automobile in England, gave a reasonably accurate picture of British street lighting practice.

(3) Mr. Rowten refers to the I.E.S. Street Lighting Committee's evaluation of several lighting systems in Detroit. His statements as to the conclusions of that group are not in accordance with the facts as published in the official minutes of this meeting.

In this evaluation, 26 qualified observers viewed seven different incandescent and fluorescent installations in the Detroit area on April 17 and 18, 1951. The observers were asked to rate each installation in accordance with the following code:

Pleasant — not noticeable as to glare	1
Barely comfortable	2
Borderline between comfort and discomfort	3
Mildly uncomfortable	4
Uncomfortable	5
Sharply uncomfortable	6
Intolerable	7

Fluorescent installations were numbers V and VI. One used a standard unit, the other an experimental model.

The average of the 26 observers was as follows:

Installation	I	II	III	IV	V	VI	VII
Average	3.0	3.8	3.7	4.9	3.3	2.3	3.6

*Author, General Electric Co., Lynn, Mass.

It will be noted that the average gave the fluorescent installations (numbers V and VI) first and third place. Note also that this evaluation was not made recently as indicated by Mr. Rowten but actually almost three years years ago which may account for Mr. Rowten's incorrect recollection.

(4) I do not believe that the condition described by Mr. Rowten is typical. Fatal or serious accidents that might be prevented by better visibility seldom occur on a street jammed with cars but rather during lighter traffic conditions where the improved visibility provided by fluorescent lighting can be, and is, an effective deterrent to these accidents.

(5) One of the points made in the original paper was that the evaluation of street lighting will require development, or at least appreciation, of a new set of values or criteria. I do not believe that Mr. Rowten's objection is significant, since evidence to date indicates that when fluorescent lighting is used a much larger variation in footcandle levels is quite acceptable from the standpoint of visibility. More data are needed and studies are being made to substantiate this contention. On the practical side, the Oakwood installation uses luminaires having the light distribution shown in the original paper and Mr. Nonneman's comment is indicative of the approval that this installation has received by both the average citizen and the qualified observer.

(6) This point is covered by Mr. Swetland's analysis.

(7) My discussions with Mr. Gaymard in England and Paris after his visit to the U. S. In addition, I have maintained contact with him since then and have just received from him a copy of the International Lighting Review (Amsterdam, Netherlands) which contains Mr. Gaymard's latest paper, "Public Lighting in France."

The article proper is preceded by this statement by Mr. Gaymard:

> "As we know, and as I shall have occasion to demonstrate a little further on, the outstanding event in public lighting of recent years is the development of fluorescent street lighting. Still, the new way of lighting is as yet far from altogether supplanting the incandescent system."

Mr. Gaymard ends his article with the following:

> "Against a single handicap, that of the bulky silhouette of the fitting (and even this inconvenience is negligible in tree-lined roads), fluorescent lighting offers such advantages in the way of pleasant appearance, visual comfort, security and economy that its rapid expansion is not to be wondered at. Whereas the French public remains reticent regarding sodium and non-corrected mercury vapour lighting, it has whole-heartedly adopted fluorescence, and it is by no means rare for the citizens of a certain district to demand the benefits of fluorescent lighting which already illuminates other streets of their town.
>
> "It is probable that this trend in favour of new light sources will continue and spread. Even where the silhouette of the fluorescent luminaires makes them less acceptable for a street without trees, the benefit of the second choice will not as a rule go to the incandescent lamp, but rather to corrected mercury vapour sources which are almost as economical as tubular lamps;"

Note that corrected mercury is still only second choice. Note also Mr. Gaymard's description of the popular enthusiasm for the benefits of fluorescent lighting.

(8) This paper was intended to be a report of observations rather than a commentary on the differences in conditions between our country and Europe. It is quite true that power rates are different in Europe and the United States. As previously stated, this differential has accentuated the swing to *vapor* sources. This power differential does not, however, account for preference of one vapor source over others since all three are of the same order of efficiency when compared to incandescent. The public wants and demands fluorescent lighting in France for the same reason as the public in England, and, I believe this preference for fluorescent is due to public appreciation backed by operational superiority. Experience to date indicates that these factors are just as important in the United States as they are in Europe. This appears to be substantiated by the fact that we have now reached the point in this country where satisfied users are extending their original installations as a result of performance and popular demand.

(9) I quite agree with Mr. Rowten in his statement that fluorescent lighting will not be sold "at present on the basis of economic consideration alone." Fluorescent lighting will be sold, and is being sold, primarily on the basis of its performance and its benefits; the American public continually demonstrates its willingness to pay a premium price for a premium article and experience to date indicates an unusual public appreciation of the benefits of fluorescent street lighting.

(10) The I.E.S. Committee recommendations on further study and development of fluorescent street lighting were made in February *1946*.

It would appear that the time for the preliminaries is past and that after eight years the public might be entitled to expect more than data from test installations. While obviously continuous future improvement and progress is to be expected, installations in the U. S. as well as in Europe and England have demonstrated the practicability and advantages of fluorescent street lighting. As in the case of interior fluorescent lighting the American public must be allowed the benefits of fluorescent street lighting during this period of further improvement.

Perhaps the best answer to Mr. Steiner's discussion would be to refer the reader to the discussion by Mr. Brown who certainly qualifies as an expert on light and visibility and to the discussion by Mr. Nonneman who can speak with authority as a user of fluorescent street lighting (and also as an extensive user of mercury lighting). I might add that comments of Messrs. Nonneman and Brown line up very closely with those which I received in Europe.

Judging from the contrast between the comments of Mr. Steiner and those of Messrs. Nonneman and Brown (plus other published opinions of other qualified experts), it would appear that perhaps Mr. Steiner might wish to avail himself of the opportunity of making some actual personal observations of modern fluorescent roadway lighting installations both in this country (there are now approximately 100 installations made since 1952) and in Europe and thus satisfy himself as to the reasons for the overwhelming preference for fluorescent lighting in Europe and the reasons for the enthusiastic acceptance of modern U. S. fluorescent installations wherever they have been made.

Questions and Answers on light sources

The I.E.S. Committee on Light Sources, under the chairmanship of H. F. Davidson, has prepared this listing of answers to frequently asked questions. Readers are invited by the Committee to submit similar questions of general interest on light sources, to be considered for publication from time to time. Questions may be sent in care of Society Headquarters.

Why are series circuit incandescent lamps rated for 6.6 amperes?

Mr. Henry Schroeder, in his booklet *History of Electric Light*, makes the following statement:

"The simplicity of the constant current transformer soon drove the constant direct-current dynamo from the market. An enclosed arc lamp was therefore developed for use on alternating constant current. . . . Two sizes of lamps were made. The transformers made for the two sizes of arc lamps produced 6.6 and 7.5 amperes, and incandescent lamps in various sizes from 16 to 50 cp were made for these currents so that the incandescent lamps could be operated on the same circuit with the arc lamps. The carbon series incandescent lamp, however, was more efficient if made for lower currents, so 3½, 4 and 5½ ampere constant current transformers were made for incandescent lamps designed for these amperes. Later, however, with the advent of the tungsten filament, the 6.6 ampere series tungsten lamp was made the standard, as it was slightly more efficient than the lower current lamps and was made in sizes from 32 to 400 cp. When the more efficient gas-filled tungsten lamps were developed, the sizes were further increased; the standard 6.6 ampere lamps were then made from 60 to 2500 cp."

Why do coefficients of utilization for reflector bulb lamp applications range as high as 1.02 whereas the coefficients of utilization never exceed 0.75 for any other type of lamp?

The coefficient of utilization expresses the percentage of the lamp lumens reaching the work plane or other reference plane. It includes the losses in the luminaire, the effect of room shape and the effect of room finishes. The average illumination is the product of the lamp lumens and the coefficient of utilization. In the usual case the lamp lumens are the same as the lumens generated by the filament. However, in the case of reflector lamps the lamp lumens are less than the lumens generated by the filament by the losses in the reflecting surfaces applied directly to the bulb. The fact that the losses in the reflector are taken into account is the reason that coefficients of utilization appear to be higher for reflector lamps than for unprocessed lamps. The correct answer will be obtained if proper lumen values are used in the computations, but care is necessary to fairly compare their utilization performance with equipments using unprocessed lamps and separate reflectors.

What is the theory of insect repellant lamps?

Investigations have shown that night flying insects are attracted by blue light and near ultraviolet energy. Therefore, any light source which lacked such energy could be employed for outdoor service to minimize the attraction of insects. Yellow is the best compromise of lamp efficiency, appearance of people and absence of blue and ultraviolet energy.

In most of my installations of standard fluorescent lamps I find a lot of dead bugs. What causes this — is it the heat or wavelength?

There is probably insufficient temperature or radiation to cause this. Insects often beat themselves to death by repeated impact or die of natural causes.

I have noticed that occasionally dark spots will develop on 40-watt fluorescent lamps directly above the louver fins. What is the cause of this?

If a cool object is close to a fluorescent lamp it may cause mercury to condense at that point on the inside wall of the lamp. The condensed mercury is the dark streak that appears.

INSTALLATION AT ST. PAUL'S CATHEDRAL, PITTSBURGH, PENNSYLVANIA.

Lighting a Cathedral

LIGHTING OBJECTIVE: To enhance the beauty of a gothic church and provide reading light for the congregation.

GENERAL INFORMATION: St. Paul's Roman Catholic Cathedral is located in the Civic Center district of Pittsburgh. As shown in Fig. 2 the body of the church is approximately 164 feet long. Ceiling height at the center of the building is 76 feet, 43 feet at the sides. The altar is white marble (75% RF); columns are gray concrete (50% RF); lower walls are oak (15% RF); floor is yellow, gray and green lino-tile (25% RF); and the pews are oak (15% RF).

INSTALLATION: Fig. 3 shows the custom-built bronze and ornamental iron luminaires (manufactured by Hymen Blum Company, Metal Craftsmen, Pittsburgh) which are spaced as shown in Fig. 2. The distance from the floor to the bottom of the units is 20 feet. Each complete assembly contains 5 200-watt inside-frosted lamps for downlighting (Pittsburgh Reflector Company Permaflectors # E-230), 6 100-watt lamps in the upper band, and 4 to 6 150-watt R-40 floodlamps to illuminate the ceiling.

(over)

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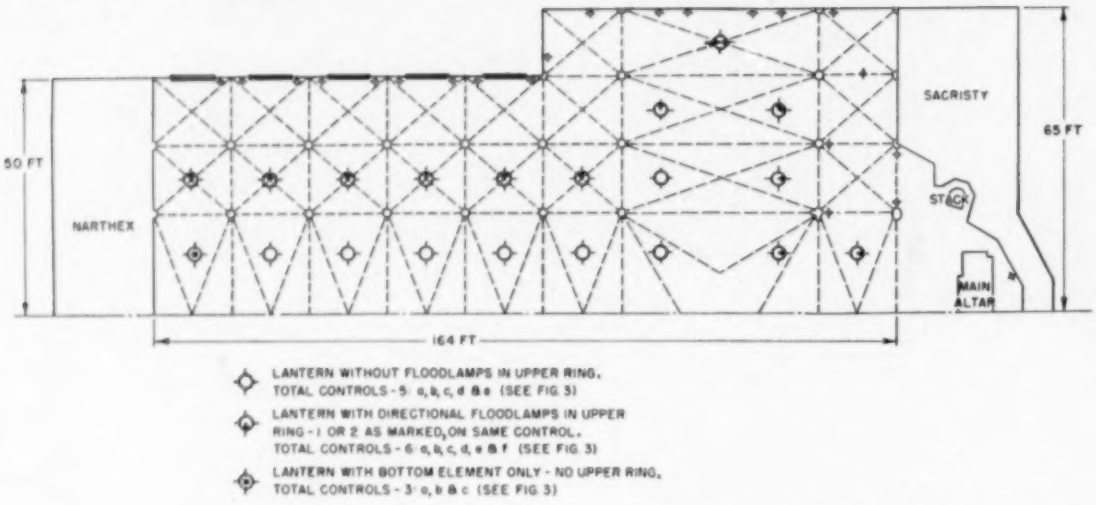
50 FT
NARTHEX
SACRISTY
65 FT
STOCK
MAIN ALTAR
164 FT
LANTERN WITHOUT FLOODLAMPS IN UPPER RING.
TOTAL CONTROLS - 5: a, b, c, d & e (SEE FIG 3)
LANTERN WITH DIRECTIONAL FLOODLAMPS IN UPPER RING - 1 OR 2 AS MARKED, ON SAME CONTROL.
TOTAL CONTROLS - 6: a, b, c, d, e & f (SEE FIG 3)
LANTERN WITH BOTTOM ELEMENT ONLY - NO UPPER RING.
TOTAL CONTROLS - 3: a, b & c (SEE FIG 3)

Figure 2. (above) Plan view of half the church showing luminaire locations.

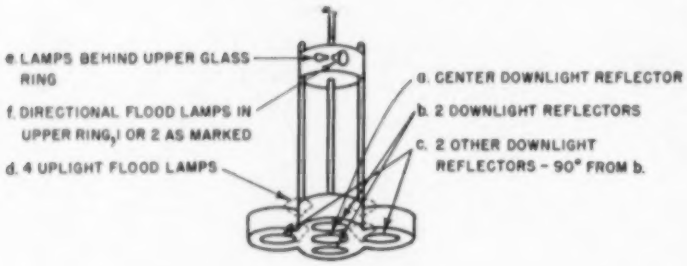
e. LAMPS BEHIND UPPER GLASS RING
f. DIRECTIONAL FLOOD LAMPS IN UPPER RING, 1 OR 2 AS MARKED
d. 4 UPLIGHT FLOOD LAMPS
a. CENTER DOWNLIGHT REFLECTOR
b. 2 DOWNLIGHT REFLECTORS
c. 2 OTHER DOWNLIGHT REFLECTORS - 90° FROM b.

Figure 3. (left) Detail of luminaire.

This installation provides 12 footcandles illumination at the pew tops and 30 footcandles at the altar. Brightnesses are as follows:

luminaire	
near horizontal	150 ft-L
bottom glass roundel at 45°	430 ft-L
top luminous band	140 ft-L
floor	3–5 ft-L
side walls	2–3 ft-L
columns	2 ft-L
pew area	½ ft-L
altar	7 ft-L

All wiring is the relay type for remote control operation. The relays are located in the basement; the control panel with push button switches and signal lights is behind the main altar.

Architects: Kaiser, Neal and Reid; electrician: Star Electric Company; lighting consultant: H. E. Sanford, Duquesne Light Company — all of Pittsburgh.

Lighting data submitted by A. G. Caplan, Duquesne Light Company, Pittsburgh, Penna., as an illustration of good lighting practice and to aid in the design of similar installations.

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Series XIX 4-54

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Technical Committees Report . . .

Aviation group schedules conference . . . AAR endorses transportation lighting report . . . Improved "Dirtometer" demonstrated . . . Searchlight problems under study . . . other technical committee activity . . .

A brief, but highly interesting report is given to Council each meeting, outlining current activity of the Society's technical committees and reporting on various studies and projects. This account, presented by Technical Director C. L. Crouch, highlights the backbone of I.E.S. work—the committees themselves, and as such is of special interest to all members. Recent reports, for instance, indicated the following:

• AVIATION LIGHTING Committee, which is practically a society in itself in this field, plans a full-scale Aviation Lighting Conference beginning April 28, in Milwaukee. At their last meeting they also decided to develop more effective liaison with other groups having similar interests, such as the Aerodromes, Air Routes and Ground Aids Subcommittee of the Air Coordinating Committee, the Instrument Society of America, the Armed Forces, NRC Vision Committee, NEMA Aviation Ground Lighting Section and others.

• CIVIL DEFENSE Committee, through which the military authorities may obtain advice on lighting problems connected with their operations, is in close touch with the Secretary of Defense Office. While much of their work is classified, it can be said that the Military is continuing its consideration of illumination control and if regulations are issued it is anticipated the Society will be identified as the organization to which all agencies (Air Force, Navy and Civil Defense Agencies) will look for technical assistance. Indoctrination meetings will be required for I.E.S. members, military personnel and numerous echelons of Civil Defense.

• JOINT I.E.S.-U. S. PUBLIC HEALTH SERVICE Committee is making progress in obtaining reactions of medical and health groups on its report "How to Make an Eye Conservation Survey." It has already received favorable response from the National Society for the Prevention of Blindness, the Joint Committee on Optics and Visual Physiology of the three national ophthalmological bodies, the U. S. Public Health Service, and the Air Force (industrial hygiene).

• The new SEARCHLIGHT Committee met for its first organized meeting at the National Bureau of Standards. Problems confronting the searchlight field were discussed, and a proposed subcommittee structure was determined to carry out studies and make reports. It was felt that this committee will satisfy a need of bringing together representatives of government, industry and consumers to study and develop solutions to common problems.

• LIGHTING MAINTENANCE Committee has learned much about the atmosphere in a number of different industrial and commercial interiors through the use of a brand new instrument developed by members of the committee. An improved model of the instrument, which they have named a "Dirtometer" was demonstrated at their last meeting, and it is expected that a number of these devices will be made up to help the committee further their experiments. The committee feels that the process of setting an approved procedure for determining maintenance factors requires pilot experiments of evaluating each element contributing to the final "maintenance factor."

• PUBLIC CONVEYANCE INTERIOR LIGHTING Committee has been active through its Subcommittee on Lighting of Buses, Trolleys and Railway Cars. This committee met with the American Association of Railroads Illumination Committee and agreed to help revise their manual in keeping with the Society's "Transportation Lighting Report" and also reflect good practice on lighting of fixed properties.

• RESEARCH FUND group has been active in developing projects that would be especially useful to the work of the Society's technical committees. The Technical Advisory Committee on Light and Vision and the Research Executive Committee recently approved two projects (1) to study the nature of specular reflectance from papers, inks and pencil commonly found in offices, schools and similar locations and develop the relationships for evaluation, and (2) to determine the distribution or scatter of

I.E.S. Regional Conferences, 1954

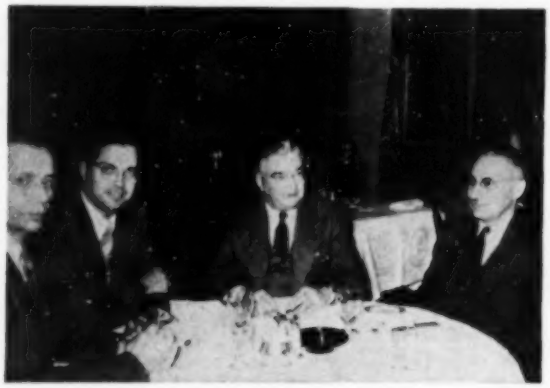
Inter-Mountain	Hotel Brown Palace Denver	April 15-16
South Pacific Coast	Museum of Art San Francisco	April 19-20
Pacific Northwest	Benjamin Franklin Hotel Seattle	April 22-23
Canadian	King Edward Hotel Toronto	April 28-30
Great Lakes	Sheraton-Cadillac Hotel Detroit	May 3-4
Northeastern	Hotel Bond Hartford	May 18
Midwestern	Jefferson Hotel St. Louis	June 17-19

I.E.S. Council Meets in New York

Every other month, October through June, the I.E.S. Council meets to conduct the business of the Society. A summary of action taken at these meetings is reported in I.E. under a heading similar to that above. The February 11 Council meeting was summed up in the March issue. Photographs on this page were taken at that meeting and during the luncheon recess.

The Society's largest Council meeting, February 11, had an attendance of 34 — Council members, proxies and others.

F. C. Winkler, Director; L. A. Hobbs, Regional V-P; L. C. Twichell; Past President S. G. Hibben; W. J. Lind, Regional V-P; and D. M. Jones, Senior Vice-President.



Willard Allphin; R. L. Biesele, proxy for Regional V-P M. J. Myers; A. F. Wakefield; and Past-President Professor Everett M. Strong.

R. F. Hartenstein, Junior Vice-President; J. R. Chambers, proxy for Midwestern Regional V-P; and E. H. Church of the Publications Committee.

A. D. Hinckley, Executive Secretary; Regional V-P. C. J. Berry; C. C. Shotwell, Director; and Bruce Jensen, proxy for W. A. Stannard.

light beam in atmospheres composed of fog and smoke and thereby study ways of improving visibility through such atmosphere.

• DAYLIGHTING Committee is watching with interest some studies underway by some of its subcommittees. One, by the subcommittee on Daylight Availability, involves a daylight survey in cooperation with the Weather Bureau. Others involve a standard test and report procedure for daylight studies, and low ceiling classrooms.

• NATIONAL DEFENSE COORDINATING Committee is giving consideration to the work which has been done relating to several Federal illumination projects, including artificial moonlight, civilian light control and a number of other matters. At a recent meeting it took action to recommend a proposed cooperative subject between the New London U. S. Naval Medical Research Laboratory and the I.E.S. Research Fund on the investigation of specular reflection of papers, inks, and pencil marks.

• GRAPHIC ARTS-PRINTING INDUSTRY, in which field an official recommended practice has long been needed, now has an active I.E.S. subcommittee studying the subject. The subcommittee has had an enthusiastic meeting with a group of experts from the graphic-arts printing industry and has laid plans for establishing separate study groups for each phase of publishing operations.

• INDUSTRIAL LIGHTING study projects nearing completion include Lighting of Sawmills — Redwood Green Chain, for one. They plan to arrange to put into actual practice in typical mills the recommendations they have so far made, and present final conclusions based on working methods of lighting the Green Chain for inspection of defects and grading.

• OFFICE LIGHTING Committee is at work on a revised Recommended Practice and so is the School Lighting Committee. The Store Lighting Committee likewise may soon come up with a revised recommended practice, particularly from the viewpoint of the store designer.

• COLOR AND ILLUMINATION Committee has underway studies on three touchy subjects — (1) Scope of the lighting engineer—to what extent should he specify color for room interiors? (2) What effect does color of environment have on the effectiveness of a lighting installation? (3) Guiding principles for the lighting engineer in the use of color for rooms. Spirited discussion has resulted in the desire to study these questions further.

• NOMENCLATURE Committee has considered the divergence of viewpoint regarding the terms of brightness and came to a solution which looks well for an early completion of the revision of the more fundamental terms relating to illumination and brightness.

• MARINE LIGHTING Committee gave consideration to the first draft of the proposed report on ship lighting and considered a number of refinements. It is believed that the report is well along and will become approved and available within the next year.

TV Show To Celebrate Light's Diamond Jubilee

Light's Diamond Jubilee Committee has announced, through its agency, N. W. Ayer & Son, that arrangements have been completed with motion picture producer, David O. Selznick, to make his debut in the television medium by personally producing a two-hour multi-network Jubilee television program, Sunday, October 24.

The Jubilee show will be aimed at the largest audience ever to witness any show in any medium, as a result of the purchase of coast-to-coast time simultaneously on three networks. The complete facilities of CBS, NBC and a third network will be utilized and their technical resources will be pooled. According to Ayer officials, details of this coverage are not yet complete, but plans are in work to use stations not yet on the air, but which will begin operations prior to the show.

Forty-three Sections and Chapters Appoint Papers Reporters

A vigorous new Society program has been inaugurated this year in 43 Sections and Chapters. This is the plan to stimulate local preparation of suitable material for publication in ILLUMINATING ENGINEERING. Considerable benefit in several quarters is expected to accrue from this local publications program. (1) Service to the industry in the presentation of application techniques and technical developments from many parts of the country. (2) Recognition to local men in

Publications Committee Prepares Its Report to Council

PUBLICATIONS Committee in action, left, at a recent meeting: l. to r., J. S. Schuchert, Chairman; C. E. Ellis, headquarters staff Advertising Manager; R. F. Hartenstein, V-P; Dr. R. M. Zabel, subcommittee on editorial content; D. M. Jones, Senior V-P. Also members but not shown are H. G. Clum, E. H. Church, G. T. Anderson and Aileen Page. In the photo at right, E. C. Huerkamp, who guided the affairs of the Publications Committee from 1949 to 1952, is a visitor at the meeting. He is currently Executive Committee Chairman of NEMA's National Relighting Program.

national publication of their ideas and installations. (3) Recognition to the local Section and Chapter.

Papers Reporters have been appointed in over half of the Society's local groups, to spearhead the program for their Section. These appointees are included in the listing of Section and Chapter Representatives to National Committees, beginning on page 34A of this issue.

Chicago School Lighting Clinic Features Educational Field Executives

The program of the School Lighting Clinic, presented March 25 by the Chicago Lighting Institute and the Chicago Section, I.E.S., was planned for school administrators, architects and health specialists as well as electrical contractors and lighting engineers. Featured on the list of speakers were superintendents of schools and state educational executives.

The morning session, under the chairmanship of Charles R. Kuglin, of Childs and Smith, Chicago architects and engineers, began with an inspection of the Institute headquarters demonstration rooms, and continued with the following lectures:

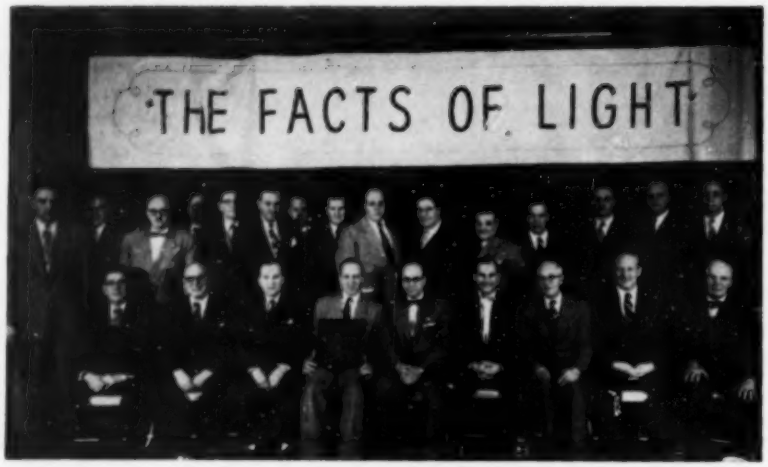
Opening Remarks — Benjamin C. Willis, General Superintendent of Schools, City of Chicago.
Visual Tasks and Environment in the School Room — Carl J. Allen and B. F. Avery, General Electric Co.
Arrangements and Types of Lighting for the Classroom — George Gilleard, Curtis Lighting Inc., and Samuel H. Eaton, Sylvania Electric Products, Inc.

Chairman of the afternoon session was the Reverend Stanley C. Stoga, Assistant Superintendent, Archdiocese of Chicago School Board. The program was as follows:

Opening Comments — M. M. Cruft, Administrative Assistant and Building Consultant to the Superintendent of Public Instruction, State of Illinois.
Lighting for Recreation — James C. Weeks, Westinghouse Electric Corp.
Lighting for Dramatics and Social Rooms — Theodore Fuchs, Professor of Dramatic Products at Northwestern University, and Consultant to Hub Electric Co.
Operating Expense of School Lighting — Eric H. Church, Benjamin Electric Mfg. Co.
Planning for Effective Daylighting — Leonard V. James, Fellow, I.E.S., and Illuminating Engineering Consultant.
Quiz the Panel — Discussion Leader, Rev. Stanley C. Stoga and panel of lecturers.

Cherchez la Femme

An I.E.S. member in the Vancouver Island Chapter, who wishes to remain anonymous, has donated prize money of five dollars to be awarded to whoever brings the first lady member into the Chapter. Chapter members are advised, however, that each such recruit will count as only one in the national membership campaign.



WHOLESALER Competition had a total of 244 entries. These 25 distributor salesmen shared the prize money of $1,340.

Pittsburgh's Second All-Industry Planned Lighting Campaign a Big Hit

More than 210 electrical industry people in the Pittsburgh area — representing manufacturers, distributors, contractors and utilities — celebrated another successful Annual All-Industry Planned Lighting Campaign. This celebration was the feature of the regular luncheon meeting of the Electric League of Western Pennsylvania on Monday, March 8, at the Hotel Roosevelt, Pittsburgh, Pa.

This second All-Industry Planned Lighting Campaign on Stores, Offices, Schools and Factories was organized and promoted again by the Commercial and Industrial Sections of the Electric League. It was initiated on October 2, 1953, with a "kick-off" dinner at Hotel Webster Hall, and it ended on January 31, 1954.

This second Campaign in the League's history produced greater results and had more support from all branches of the local lighting industry than the first activity of 1952-1953. It was supported by three lamp manufacturers, eleven distributors, the Western Pennsylvania Chapter of NECA, and the Commercial and Industrial Sales Departments of Duquesne Light Company. These organizations cooperated not only in spirit and physical energies, they also contributed to a Campaign Fund. This Fund was of sufficient size to pay the expenses of a "Kick-Off" Dinner for 150 individuals, two honorary plaques, total cash awards of $2,000 to contractor and distributor representatives, and incidental expenses in printing, mailings and other promotional measures.

A total of $1,340 was awarded to twenty-five representatives of the participating wholesalers. This sales personnel of 11 cooperating distributors made a total of 244 entries to the Wholesaler Competition. In this competition each entry, if it met minimum standards of the I.E.S. as to quantity and quality of illumination, scored points according to a rising scale of values. Each point had a monetary value of forty cents.

The four top awards to the distributor personnel were: M. B. Schutzer, Pittsburgh Electric, $284.20; L. D. Ecoff, Keps Electric, $256.60; J. X. Britton, National Electric, $173.80; and C. M. Hermes, Doubleday Hill, $129.20.

Other wholesaler people sharing in the total awards of $1,340 were: L. A. Segal, Wally Electric, $66.00; J. R. Mahaffey, Wesco, $61.00; J. E. Emery, Graybar, $40.40; D. P. Wisner, Doubleday Hill, $36.40; J. W. Hobe, Gesco, $33.20; G. C. Dankmyer, Wesco, $30.00; T. E. Pfischer, Wesco, $30.00; J. H. Phillips, Graybar, $29.20; Harold Stein, Keps, $25.20; C. E. Albro, Gesco, $17.20; F. R. Woodworth, Keps, $17.20; J. J. McCoy, Gesco, $17.20; H. O. Catherman, Wesco, $16.00; W. C. Lyle, Doubleday Hill, $15.60; C. W. Jones, Gesco, $14.00; W. H. Wayman, Graybar, $9.60; J. C. Haines, Wesco, $8.80 H. B. Drake, Graybar, $8.40; Peter Fitzurka, Graybar, $8.00; R. N. McCoy, Graybar, $6.00; Gordon Goerman, Doubleday Hill, $5.20.

One of the features of the Campaign is the award of an honorary plaque to the electrical contractor organization and to the distributor group, performing the best jobs during the Campaign term of four months. For the second time in suc-

cession the honorary plaque for wholesalers was awarded to Keps Electric Company. Out of the total of 244 entries by wholesalers, Keps had the most entries with 56 and scored more points per person registered in the Campaign. But the competition was sharp and close with Pittsburgh Electric Supply Company, in Second; National Electric Supply Company, in Third; and Doubleday Hill, in Fourth Place.

Also, for the second time in succession, the honorary plaque for electrical contractors was awarded to Frame Electric Company. This organization made the most entries to the Contractor Competition, won two top awards, and had the most entries of top-notch quality. Close on the heels of Frame Electric in this competition were F. R. Haubelt Electric and Reno Electric Company.

In the Contractor Competition there were a total of 82 entries of installations during 1953. A Committee of Judges (C. M. Crysler, H. S. James, L. T. Kight, C. D. Miller, A. Paulus, D. C. Thomas) visited the installations and judged them according to modern standards, practices and techniques.

The prize-winning installations and contractors were as follows:

Light for Selling Classification

First Prize — $75.00
To: Frame Electric Company
For: B & G Restaurant
Alcoa Building

Second Prize — $50.00
To: Koch Electric Company
For: Dorsch Shoe Store
700 E. Ohio Street

Third Prize — $25.00
To: F. R. Haubelt Electric Company
For: Algeo Pharmacy
Mt. Lebanon

Fourth Prize — $15.00
To: Prothero Electric Company
For: Rowse Drug Store
Beaver, Pa.

Light for Schools Classification

First Prize — $75.00
To: J. Fink Electric Company
For: Wilson School
Clairton, Pa.

Second Prize — $50.00
To: Herman Eidinger
For: Mother of Good Counsel School
Homewood

Third Prize — $25.00
To: Martin Electric Company, Inc.
For: Hawthorne Elementary School
Forest Hills

Fourth Prize — $15.00
To: Reno Electric Company
For: Hopewell Raccoon Independence School
Raccoon Township

(Continued on page 11A)

LIGHTING CALENDAR

Society Events

April 15-16, 1954—Inter-Mountain Regional Conference, Hotel Brown Palace, Denver, Colo.

April 19-20, 1954—South Pacific Coast Regional Conference, Museum of Art, San Francisco, Calif.

April 22-23, 1954 — Pacific Northwest Regional Conference, Benjamin Franklin Hotel, Seattle, Wash.

April 28-30, 1954—Canadian Regional Conference, King Edward Hotel, Toronto, Ont.

May 3-4, 1954 — Great Lakes Regional Conference, Sheraton-Cadillac Hotel, Detroit, Mich.

May 18, 1954—Northeastern Regional Conference, Hotel Bond, Hartford, Conn.

June 10, 1954—Meeting of the I.E.S. Council, New York, N. Y.

June 17-19, 1954—Midwestern Regional Conference, Jefferson Hotel, St. Louis, Mo.

September 13-17, 1954—Illuminating Engineering Society, National Technical Conference, Chalfonte-Haddon Hall, Atlantic City, N. J.

Industry Events

May 3-7, 1954 — Society of Motion Picture and Television Engineers, Semi-Annual Convention, Hotel Statler, Washington, D. C.

May 13-14, 1954 — Public Utilities Advertising Association, National Convention, Hotel Statler, Boston, Mass.

May 17-20, 1954 — Basic Materials Exposition, International Amphitheatre, Chicago, Ill.

May 19-21, 1954 — Pacific Coast Electrical Association, Inc., Hotel Del Coronado, Coronado, Calif.

June 6-11, 1954 — National Association of Electrical Distributors, 46th Annual Convention, Atlantic City, N. J.

June 7, 1954, Week of — Society of the Plastics Industry, Sixth National Exposition, Cleveland, Ohio.

June 20-24, 1954 — The American Society of Mechanical Engineers, Semi-Annual Meeting, William Penn Hotel, Pittsburgh, Pa.

July 13-15, 1954 — Western Plant Maintenance Show, Pan Pacific Auditorium, Los Angeles, Calif.

June 21-25, 1954 — American Institute of Electrical Engineers, Summer General Meeting, Los Angeles, Calif.

September 8-10, 1954—The American Society of Mechanical Engineers, Fall Meeting, Schroeder Hotel, Milwaukee, Wis.

September 22-24, 1954—Canadian Electrical Manufacturers Association, General Brock Hotel, Niagara Falls, Ont., Canada.

September 29 - October 2, 1954 — International Association of Electrical Leagues, Bellevue Stratford Hotel, Philadelphia, Pa.

October 4-7, 1954 — National Association of Electrical Distributors, Pacific Zone Convention, Mark Hopkins Hotel, San Francisco, Calif.

October 11-15, 1954—American Institute of Electrical Engineers, Fall General Meeting, Chicago, Ill.

October 17-22, 1954—Society of Motion Picture and Television Engineers, Semi-annual Convention, Los Angeles Ambassador, Los Angeles, Calif.

October 18-22, 1954—42nd National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

October 24-27, 1954 — Board of Governors, National Association of Electrical Distributors, Hershey Hotel, Hershey, Pa.

November 8-11, 1954 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

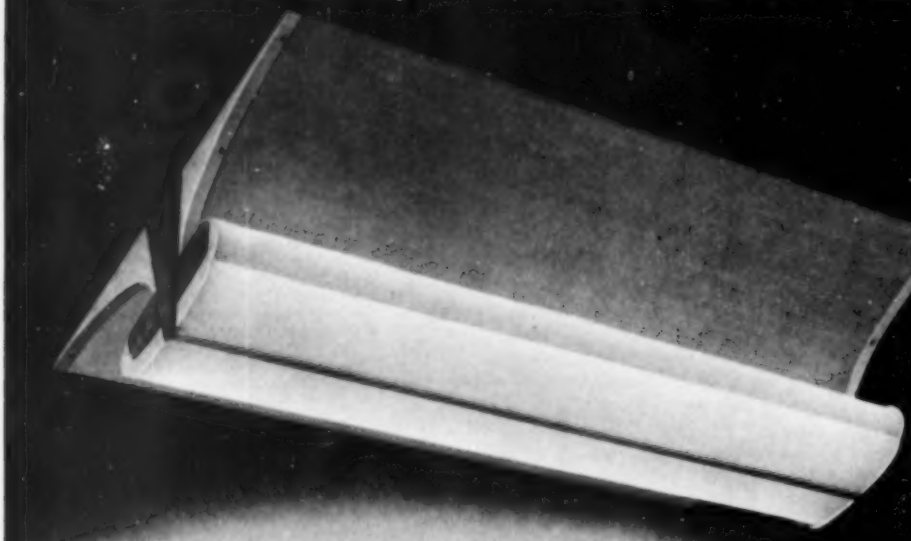
November 15-17, 1954 — 41st National Foreign Trade Convention, Waldorf-Astoria Hotel, New York, N. Y.

November 15-17, 1954 — American Standards Association, 5th National Conference on Standards and 36th Annual Meeting, Hotel Roosevelt, New York, N. Y.

November 28 - December 3, 1954 — The American Society of Mechanical Engineers, Annual Meeting, Statler Hotel, New York, N. Y.

CONTRACTOR Competition in the All-Industry Planned Lighting Campaign held in Pittsburgh drew a total of 82 entries. This group of prize-winning contractors shared in the 16 awards.

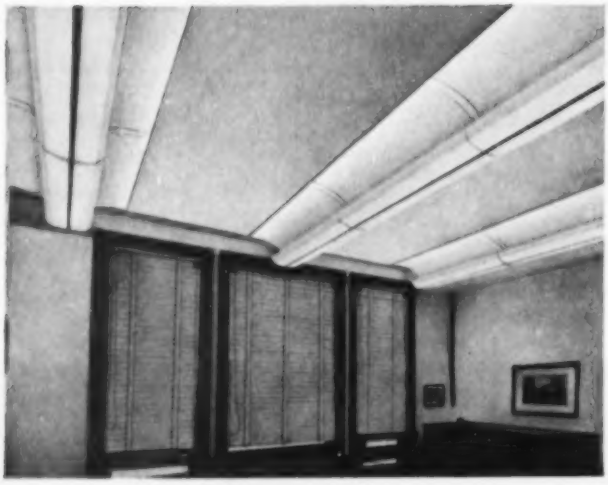
SYLVANIA ANNOUNCES—



Close-up of Sylvania Sono-Lume unit showing perforated metal wings backed with sound-deadening glass fiber batting. Fixtures may be also equipped with louvers instead of plastic shielding. Mounted singly or in continuous rows.

SONO-LUME.....

the Fixture† which Controls Sight and Sound



New fluorescent lighting fixture has built-in sound-conditioning system . . . easily installed!

Now Sylvania introduces SONO-LUME . . . a new concept of sight and sound control!

Basically, Sono-Lume is an attractive fluorescent fixture incorporating principles worked out by Sylvania engineers.

The perforated wings on each side of Sono-Lume fixtures are backed with glass fiber batting. This element has the excellent noise reduction coefficient of 0.85. Thus the fixture serves a double purpose: (1) It provides high levels of clear, soft, all-over illumination for comfortable seeing. (2) It holds unnecessary noise to low levels for comfortable hearing.

Saves modernization costs!

Sylvania Sono-Lume fixtures can be readily installed in any office, conference or consultation room. In instances where sound-proofing and better lighting are separate projects, this new combination fixture keeps costs well within modest budgets. A note on your letter-head will bring you detailed information. Simply address Dept. 4X-3504, at Sylvania.

*Sylvania Trade Mark
†Patent Pending

SYLVANIA

Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.

In Canada: Sylvania Electric (Canada) Ltd., University Tower Bldg., St. Catherine Street, Montreal, P. Q.

LIGHTING · RADIO · ELECTRONICS · TELEVISION

(Continued from page 9A)

Light for Production Classification

First Prize — $75.00
To: Frame Electric Company
For: Williams and Company, Inc.
Pennsylvania Avenue

Second Prize — $50.00
To: Lord Electric Company, Inc.
For: Du Mont Studios
Gateway Center

Third Prize — $25.00
To: F. R. Haubelt Electric Company
For: Bushnell Machinery Company
Dormont

Fourth Prize — $15.00
To: Franklin Electric Construction Co.
For: F. J. Kress Box Company
#1 28th Street

Light for Atmosphere Classification

First Prize — $75.00
To: Thomas P. Hanlon
For: Sixth United Presbyterian Church
East Liberty

Second Prize — $50.00
To: A. C. Electric Company
For: Oakmont M. E. Church

Third Prize — $25.00
To: Haber Electric Company
For: Anne Ashley M. E. Church
Munhall

Fourth Prize — $15.00
To: Reno Electric Company
For: C.I.O. Steelworkers Union
2325 E. Carson Street

Guest speaker at the luncheon, on the subject of the "Facts of Light" was Joseph S. Schuchert, Manager, Commercial Sales Department, Duquesne Light Company. Mr. Schuchert also made the award presentations assisted by Gordon Maize, the Campaign's General Chairman, and Miss Eleanor Schano, one of Pittsburgh's loveliest models, acting in this case as Miss "Industry Cooperation."

A Task Committee responsible for all the arrangements was headed by Harry Johns, the League's Manager, and included A. R. Hampsey, W. E. Eisenhauer, Carl Taylor, Jack Gottfried, A. Paulus, Cory Crysler, William Mock, and Don Thomas.

Career Conference Helps Chicago Area Students

The 6th Annual Chicago Area Career Conference was held March 20 at the Illinois Institute of Technology. Sponsored jointly by the Institute of Technology, the Chicago *Sun-Times*, and the Chicago Technical Societies Council, with Herbert F. Schwarz as general chairman, the Conference brought together the largest gathering to date of high school students seeking information on the selection of courses to prepare them for their careers.

STANDING at the entrance to the Milwaukee exhibit on the history of light sources are, left to right: T. B. Dustin, vice-chairman of the Milwaukee Section; William Lisch, Section secretary; C. N. Laupp, past V-P of the Midwestern Region; and Section member J. H. Wanska.

History of Lighting Traced At Milwaukee Exhibit

A lighting exhibit, sponsored jointly by the Milwaukee Section of I.E.S. and the Milwaukee Museum, demonstrates the history of light sources from ancient times up to the present. Clay lamps as used in ancient Greece and Rome; pricket candlesticks and Jewish lamps from Medieval times; lamps developed in Colonial America; the improved kerosene lamps of Victorian era, bring the history of lighting up to the electric age. A physics display bridges the gap to the exhibits of the many modern sources in use today.

Eldon G. Wolff, Curator of History of the Milwaukee Museum, cooperated with Section members in making the display possible.

Lighting Seminar Held In Heart of America Section

Six classes, with emphasis on the practical aspects of lighting, comprise the lighting seminar sponsored by the I.E.S. Heart of America Section. The two-hour sessions, held at the Lighting Institute of the Kansas City Power and Light Co., in Kansas City, Missouri, were under the general direction of Carl W. Thorsell, Chairman of the Section's Committee on Education. Section members served as lecturers for the seminars. Topics covered and lecturers for them were:

March 4 — Review of Lighting Fundamentals: R. R. Marvin.
March 11 — Characteristics of Lighting Sources: J. Gordon McDonald.
March 18 — Industrial Lighting Applications, Engineering: C. W. Thorsell.
March 25 — Display Lighting Design: Francis O'Connor.
April 1 — Designing Outdoor Flood and Spot Lighting: Ray Perry.
April 8 — School and Office Lighting — Theory and Methods: Marshall A. Havenhill.

An interesting feature of this seminar is that all members of the class who completed five of the six sessions received as a gift an up-to-date leatherette-covered handbook on lighting.

Cincinnati Societies Sponsor Professional Development Program

Five major engineering societies of the Cincinnati industrial area met recently for a joint professional development program. This was the first step in a concerted action on the part of the five societies relative to the ECPD Professional Training program for young graduate engineers, known as the "First Five Years of Professional Development."

Local sections of the American Institute of Chemical Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, and American Society of Civil Engineers joined with the Engineering Society of Cincinnati in staging the program.

Following the keynote address by S. D. Kirkpatrick, past president of AIChE, vice-president and editorial director of the McGraw-Hill Book Co., the audience was divided into eight discussion groups for round-table sessions relating to the six points of the ECPD program. Subject discussed included: Orientation and Training in Industry; Continued Education; Integration into the Community;

(Continued on page 12A)

(Continued from page 11A)

Professional Registration; Self Appraisal; Selected Reading.

Each of the five societies participating designated eight key members to assist in leading these group discussions.

The forty society representatives who served in leading the eight discussion groups represented 32 industries and engineering companies in the Cincinnati area. The meeting was another in the steps of the ECPD pilot study known as the "Community Project in Professional Development" which is emphasizing the importance of related activities of industry, the engineering societies and the universities on a community basis in a typical industrial area. A report on this study will be given at the ECPD annual meeting in Cincinnati next October, and plans are now under way to establish similar projects in industrial areas throughout the United States and Canada.

Joint Meeting in Montreal Features Lighting Clinic

The Montreal Section of I.E.S. and the Electrical Club of Montreal held a joint luncheon meeting and afternoon clinic on lighting, at the Queen's Hotel, March 10. R. S. Tate, Canadian General Electric Co., presided as chairman.

Subjects and speakers at the afternoon clinic were:

Light Fantastic — R. A. Eshelby, Northern Electric Co., Ltd.

Recent Lamp Development (Rapid Start) — T. C. Sargent, Sylvania Electric Products, Inc.

A Study of Rapid Start Ballast — A. H. Tutte, Canadian General Electric Co., Ltd.

Design Problems in Lighting — M. G. Spankie, J. P. Keith and Associates.

ABOUT PEOPLE

Caroline E. Horn, for many years Assistant Engineer in the Photometric Department of Electrical Testing Laboratories, New York, retired as of March 1. One of the best-known figures in the lighting industry, Miss Horn was equally distinguished in I.E.S. circles. In addition to serving on numerous committees, both as chairman and member, she has the distinction of being the only woman elected as Chairman of an I.E.S. Section (New York Section 1948-1949) and served as Secretary, New York Section, 1944-1946.

The Gold Medal Award "for distinguished engineering service," highest honor bestowed by the Colorado Engineering Council, was presented to **Lawrence M. Robertson,** Chief Electrical Engineer of the Public Service Co. of Colorado, at a meeting of the Council February 26. Mr. Robertson has supervised the electrical engineering of some of the larger private power developments in the western part of the country, and has contributed extensively in the field of engineering education. He is the sixth person to receiev this award in the 35-year history of the Council.

William H. Tomb, Jr., manager of specialty products sales at Corning Glass Works since 1948, has been appointed to the newly-created position of merchandising manager for the company's Technical Products Division. Succeeding Mr. Tomb is **D. J. Lammon,** who has been manager of appliance parts sales since 1951.

Robert S. Wiseman, of the Engineering Research and Development Laboratories, Fort Belvoir, Va., has just received his doctor's degree from the University of Illinois with a major in illumination. Dr. Wiseman, who was formerly with the electrical engineering department at Mississippi State College, has recently been appointed chief of the Research and Photometric Section of the Electrical Engineering Department's Night Vision Equipment Branch of E.R.D.L.

Carl R. Busch has taken a position as Project Engineer with Aeronautical Radio, Inc., with headquarters at 1520 New Hampshire Ave., N. W., Washington, D. C. Mr. Busch was formerly Associate Engineer with Commonwealth Associates, Inc., in Jackson, Mich.

Richard Wessling, formerly vice-president and director of Electric Supply Corp. of Chicago, Aurora, Hammond, and Milwaukee, has been named District Manager of the Chicago office of the Allen-Bradley Co., electric control manufacturers of Milwaukee. He succeeds **John McC. Price,** former district manager, who has retired from active service.

Robert G. Ely, sales vice-president of the Connecticut Light and Power Co., died suddenly at his home in Farmington, Connecticut, on February 20 of a heart attack. Mr. Ely had been appointed director of sales for the company in 1951, and was elected vice-president in charge of sales a year later. Before joining C. L. and P. three years ago, he had been assistant manager of industrial power sales for the Public Service Electric and Gas Company of New Jersey.

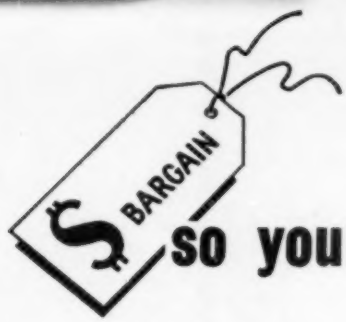
James E. McComack has been named Southeastern Engineering and Sales Department representative for the Perfeclite Co., of Cleveland. Mr. McComack, who was most recently with the Noland Co., Inc., will cover the states of Georgia, Alabama, Florida, North Carolina, South Carolina, Virginia and Tennessee, with temporary headquarters at 129 Interlochen Drive, N. W., in Atlanta, Ga.

Acme Electric Corp., Cuba, N. Y., has announced the election of **Curtis F. Falldine** as Treasurer and **Carl J. Anderson** as Secretary. Mr. Falldine was previously Controller and Mr. Anderson Assistant Treasurer for the company.

The appointment of **Campbell Rutledge, Jr.,** as general sales manager of the New Products Division at Corning Glass Works has been announced. He succeeds **George H. L. Norman** who has resigned.

(Continued on page 15A)

PRE-CHARTER MEETING of the new Ark-La-Tex Chapter of I.E.S. was held February 1, with an attendance of 30. Speaker at the meeting was H. R. Wells of du Pont Company, who spoke on Color and Lighting. The group's application for for a Charter was approved by Council in February.



so you think you're saving money?

Far too often people figure lighting fixtures are all alike and buy by price tag alone. You may save a dollar or two on the price of each unit, but are you really saving money?

Today's carefully engineered lighting installations are planned with units that are designed to deliver more light at less cost. *Fewer units are required to secure the same results.* So, installation costs are less. And most important, power and maintenance costs are less during the whole life of the installation.

Take the Smithcraft DIRECTOR, for example. A recent comparison test by one of the nation's leading electric utilities clearly demonstrates that the Director produces more light and better light than ordinary fixtures.

Installed in literally thousands of banks, stores, schools and similar locations across the United States, the Smithcraft Director is in a class by itself for appearance, for quality of lighting and for soundness of investment. Be sure to get the complete story on the Smithcraft Director before relighting or when planning new installations. Ask us to send you our Smithcraft Director folder.

Photograph shows Director installation in the offices of the Credit Representative of the First National Bank of Boston, Empire State Building, New York.

BUY LIGHTING — NOT FIXTURES. INVEST IN AMERICA'S FINEST FLUORESCENT LIGHTING by
Smithcraft
LIGHTING DIVISION
CHELSEA 50, MASSACHUSETTS

the P&K story

HIGHWAYS

DRIVE-INS

BETTER LIGHTING everywhere

SHOPPING CENTERS

PARKING AREAS

RECREATION AREAS

AT LOWER COST to everybody

Pfaff & Kendall, originator of the Seamless Tapered Aluminum Lighting Standard and Tapered Elliptical Arm, is now producing designs and types to meet any highway, road, area, bridge and traffic signal requirement.

Wherever P & K All-Aluminum Standards and Brackets are specified and installed, the story is the same: *Fewer technical problems . . . rapid, easy installation . . . greater lighting efficiency . . . and the kind of economy you can figure in actual dollars!*

P & K All-Aluminum Standards and Brackets are always the wisest choice . . .

LIGHT WEIGHT for lowest cost installation.
NEGLIGIBLE CORROSION for longest service.
NO PAINTING means large, year-after-year savings.
SALVAGEABLE, RE-USABLE in event of knockdown.

WRITE FOR LATEST P & K CATALOG... and use the P & K planning and advisory services without obligation.

Pfaff & Kendall
84 Foundry Street
Newark 5, New Jersey

(Continued from page 12A)

Joseph G. Lipkins, executive vice-president of Broadway Maintenance Corp., Long Island City, N. Y., has been elected president of the National Electric Sign Association at its 8th annual convention in Chicago.

Edward Balogh, of the I.E.S. Southern California Section, formerly with Sunbeam Lighting Co., is now associated with Lou Black & Associates, Los Angeles, manufacturers representative. **Tom McCabe**, formerly with Welcon Becket Architects, has replaced Mr. Balogh at Sunbeam Lighting.

Roger H. Bolin has been named manager of general advertising for Westinghouse Electric Corp., with headquarters in the company's Pittsburgh office.

Hal Levy, formerly of Globe Lighting's California branch, is now associated with Nu-Lite Fluorescent Mfg. Co., Inc., in Los Angeles.

BOOKS AND PAMPHLETS

*Books whose reviews are marked * are available for inspection at the I.E.S. Headquarters Office Technical Dept.*

***Illumination Engineering** by Warren B. Boast, Second Edition published by McGraw-Hill Book Company, 1953; 351 6 x 9 inch page, 159 illustrations; price $7.00.

This revision brings Dr. Boast's excellent 1942 textbook up to date. The book stresses lighting calculations and was written for undergraduate illuminating engineering students. The author is Professor of Electrical Engineering at Iowa State College.

As in the first edition no photographs of lighting installations are included. One special feature is the listing at the beginning of each chapter of definitions of all new terms used in the chapter. Numerous tables of current data on lighting equipment will make the book useful for reference purposes.

Chapter headings are as follows: The Spectroradiometric Function, The Luminosity Function, The Illumination System, Entities in the Illumination System and their Units, Measurement of Illumination, Geometric Graphs and Their Application, Determination of Illumination from Surfnce and Line Sources, Absorption, Reflection, and Transmission of Luminous Flux, Electric-Light Sources and Their Operating Characteristics, Illumination Standards, Lumen Method of Design of Interior Lighting Systems Using Commercial Luminaires, Illumination and Brightness Design by the Interreflection Method, Luminous Architectural Elements, Testing of Illumination Systems, Color Specifications, Design of Floodlighting Systems, Design of Streetlighting Systems, Ultraviolet and Infrared Sources and Applications, and Wiring.

***Daylight** by John Swarbrick, published by the Wykeham Press, London, 1953; 79 6 x 9½-inch pages, 43 illustrations; price 20s, plus 1s6d postage to U.S.A. (approx. total, $3.00).

This little book was written by an architect for architects, town planners, and public health and social welfare workers. Chapter headings are as follows:

I — The Nature and Therapeutic Properties of Daylight.

II — Daylight Measurement.

III — The Penetration of Sunlight.

IV — Regarding the Law of Light and Legal Practice in England.

Appendix I — Lambert's Cosine Law of Light.

Appendix II — Mathematical Explanation of the Method of Measuring Daylight by Projecting the Solid Angle of Light Upon the Horizontal Plane.

Most of the technical content of this book is based on the British "daylight factor" system of design and British building codes. The volume should prove valuable to daylighting specialists and architects but probably will not be of interest to lighting engineers in general. The author presents many interesting historical architectural observations as well as short cuts to computing daylight factors accurately by simple arithmetic.

To encourage householders to make their gardens as attractive by night as by day is the purpose of a new 48-page illustrated booklet, **Garden Lighting**, published by Edythe Polster, New York, N. Y. A complete reference on the subject, the booklet was written by Edythe Polster, author of many articles on lighting and better living, and Myrtle Fahsbender, director of residential lighting for the Westinghouse Lamp Division, Bloomfield, N. J. The booklet contains 28 photographs of distinctively-lighted gardens and 43 sketches of practical garden fixtures drawn by Janet Schirn.

Included is a do-it-yourself section, with practical suggestions for constructing homemade housings, as well as a guide to ready-made lighting equipment available for a multitude of specific needs.

The booklet, which sells for $1.00 a copy, may be obtained by writing the Residential Lighting Department, Westinghouse Lamp Division, Bloomfield, N. J.

NEW MEMBERS

At the meeting of the I.E.S. Council Executive Committe held in New York, March 11, 1954, the following were elected to membership. Names marked * are transfers from Associate Member grade.

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Roberts, John, Jr., Carneal & Johnston, Richmond, Va.
Sowers, W. A., Sowers, Knowles & Rodes, Roanoke, Va.
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MacKenzie, D. E., George B. Rottman, Greensboro, N. C.
Maddocks, D. L., Macklin & Stinson, Winston Salem, N. C.
Morrison, M. E., Insterstate Electric, Charlotte, N. C.
Owens, R. M., Electric Supply & Equipment Co. Inc., Greensboro, N. C.
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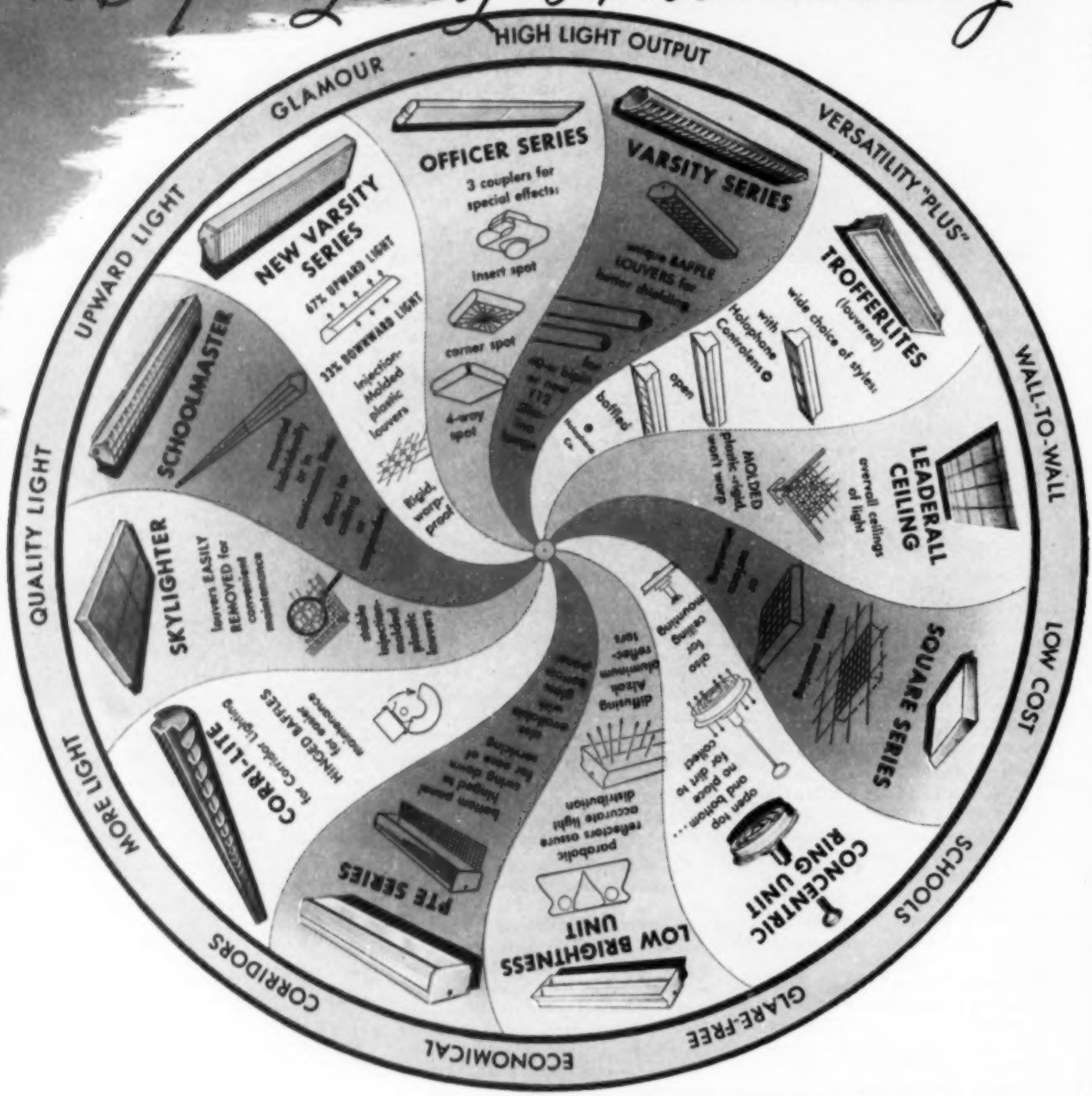
(Continued on page 38A)

the Benjamin Leader Line...First in Versatility



Nothing is left to chance or compromise when you choose from the Benjamin Leader Line "Wheel of Versatility." One look at the wide range of fixtures and features tells why the Benjamin Leader Line is FIRST in Versatility, no matter what your basis for selecting lighting equipment. Be it first cost or economical upkeep... lighting for effect or high footcandle levels... whether you're trying to match existing architectural treatment or striving to achieve a new, modern decor... Benjamin Leader Line VERSATILITY enables you to find exactly the lighting unit you need. FREE Catalog Data Sheets contain complete details.

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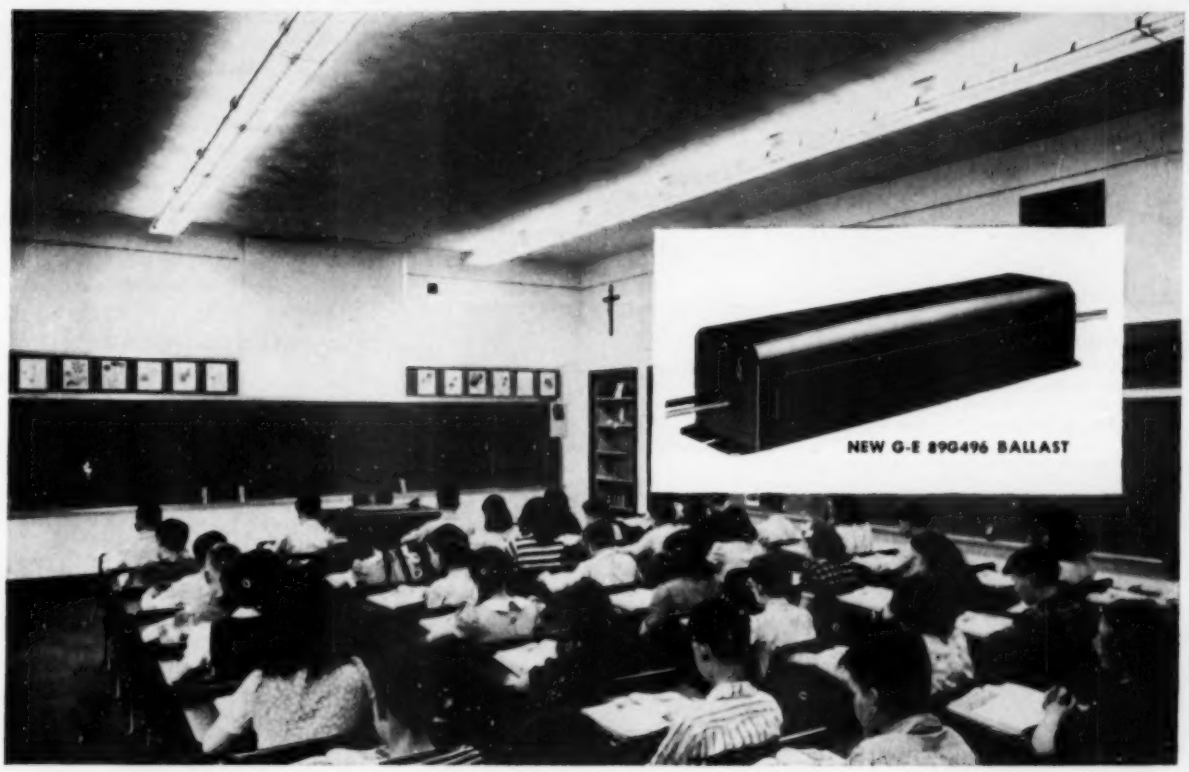
(*Continued on page* 21A)



New G-E Ballast for 96T12 Lamps

QUIETER, SMALLER, LIGHTER

The new G-E ballast for 96T12 lamps has been redesigned so that it is now shorter, lighter and *quieter.* Yes, *quieter.* Now for the first time General Electric offers you a ballast for 96T12 lamps that has a "D" sound rating. This lower noise level makes operation possible in a variety of new applications. Fixtures equipped with this new G-E ballast are now suitable for schools, hospitals, libraries and many other installations where noise is a problem.

The new ballast is only 11¾ inches long. The shorter length—3⅛ inches less than the old design—means reduced handling and storage problems for you.

This new series ballast weighs only 10½ pounds—a reduction of 1¾ pounds over the old design. This means savings in shipping costs for both manufacturer and distributors.

By redesigning, this ballast has been changed from an "E" to a "D" sound rating. Manufacturers can now use this new G-E series ballast in fixtures installed in many low-noise areas.

For further information on sound rating and G-E ballasts send the coupon below to General Electric Company, Schenectady 5, N. Y.

Section A 401-5
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Please send me new bulletin GEA-5672, "How to put Sound Rating to Work."

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Progress is our most important product

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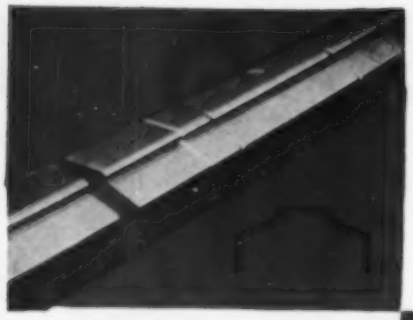

LOCKED IN PERFECT ALIGNMENT

Uni-Race sections slide into a firm telescopic union with coupler forming a rigid channel that will not distort (even before screws are added) and assures perfect fixture alignment.

THE NEW

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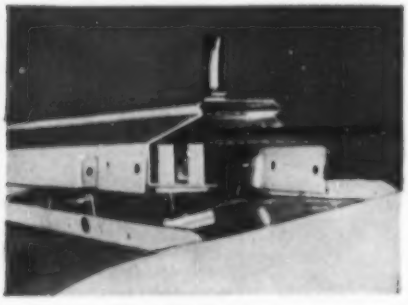
Acclaimed by lighting experts everywhere as "ushering in a new era in fluorescent fixture design"; the spectacular new Ortho-77 by Gibson is an entirely new concept of fixture design. Incorporated for the first time on any fluorescent fixture are a multitude of features that simplify installation, provide position alignment and spacing and give greater fixture rigidity. Now without tools and in a matter of minutes you can change fixtures instead of ballasts . . . raise lighting levels from two to four light or vary the levels as conditions demand . . . install fixtures at intervals automatically spaced and fill in quickly and easily as needed. Contractors have claimed as much as 50% saving in installation time with the Ortho-77 which means that you, the user, can install this revolutionary fixture incorporating the new Uni-Race, "V" type integrated construction, simplified plug-in wiring and many other features at no greater cost than a conventional installation. See it at your jobber today or write for bulletin Ort-101 for complete information.

RIGID CHANNEL ANCHOR

Light in weight, readily accessible and easily mounted, the Uni-Race provides a rigid channel anchor for all Ortho-77 models. Being machined to exceptional tolerances, it automatically provides for exact fixture spacing.



PLUG-IN SOCKET

Ortho-77 units are wired to a Plug-In Socket which makes contact with a receptacle in the Uni-Race when fixture is closed. Fixture becomes completely dead when open, and being wired in parallel circuits, does not disturb other fixtures when removed.

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(Continued from page 18A)

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(Continued on page 23A)

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(Continued from page 21A)

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I.E.S. National Technical Conferences

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September 12-16, 1955 — Statler Hotel, Cleveland

September 16-21, 1956 — Statler Hotel, Boston.

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Marshall, Texas—D. M. Mack, Southwestern Gas & Electric Co.
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Clifton W. Whitmore

Home Lighting Data Sheets

Aileen Page, Chairman, General Electric Co., Cleveland, Ohio.

Marian Amabary — Jan Reynolds
Edith Buchholtz — Ruth Schmoll
Melrose Franklin — Blanche Waggener

GENERAL COMMITTEES

ADVANCE PLANNING—To study the operation, program, publication activities, membership classifications and financial structure with a view of its immediate and long-range objectives and to make recommendations to Council.

C. C. Keller, Chairman, Holophane Co., Inc., 342 Madison Ave., New York, N. Y.

R. L. Biesele, Jr. — W. P. Lowell
B. J. Jensen — E. M. Strong
J. F. Whitehead, Jr.

ADVISORY BOARD ON COMMITTEE PERSONNEL — To examine the organization, accomplishments, and assignments of committees and prepare not later than July 1st of each year a proposed list of committees and personnel.

D. M. Jones, Chairman, Curtis Lighting Co. of Canada, Ltd., 991 St. Antoine St., Montreal W, Que.

C. L. Crouch — R. F. Hartenstein
C. C. Keller — A. D. Hinckley
E. M. Strong

BOARD OF NOMINATION — To prepare a nomination ticket containing the names of those who are deemed best suited to serve as officers and directors in positions to be filled at the ensuing election.

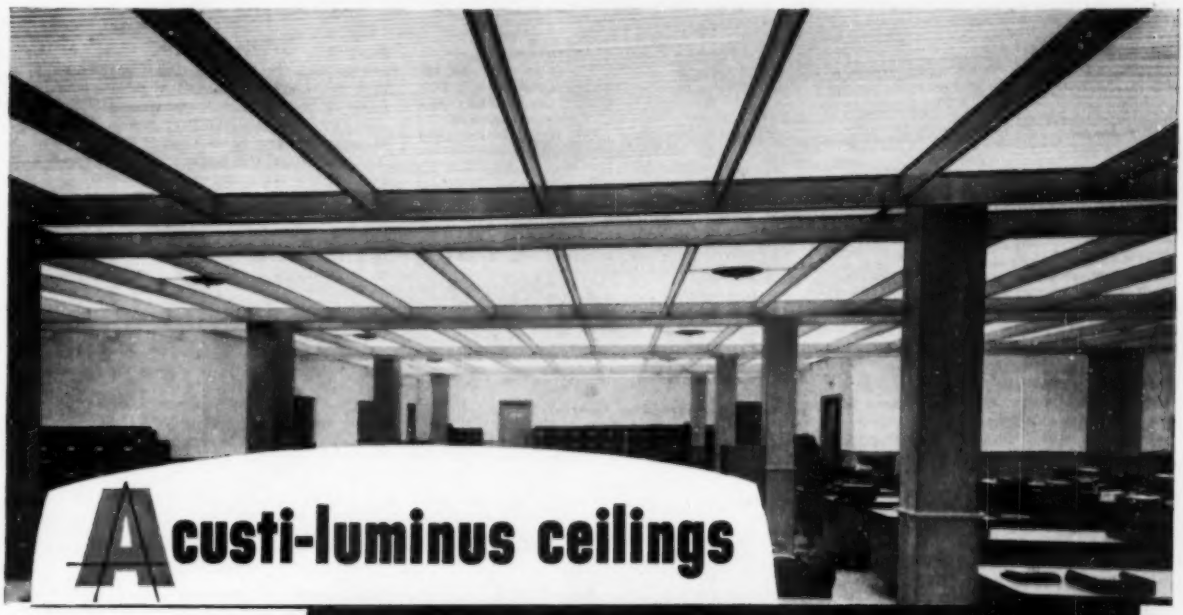
Walter Sturrock, Chairman, General Electric Co., Nela Park, Cleveland, Ohio.

S. G. Hibben — E. M. Strong

Regional Representatives

C. J. Berry — W. J. Lind
C. H. Church — M. J. Myers, Jr.
M. B. Hastings — G. E. Park
S. H. Hazleton, Jr. — L. E. Tayler
L. A. Hobbs — G. J. Taylor

(*Continued on page* 26A)



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CONSTITUTION AND BY-LAWS — To prepare for Council proposed amendments to the Constitution.

Walter Sturrock, Chairman, General Electric Company, Nela Park, Cleveland, Ohio

G. W. Beals	Myrtle Fahsbender
G. F. Dean	G. K. Hardacre

COORDINATING COMMITTEE FOR DEFENSE — To contact various Government Agencies concerned with National Security suggesting cooperation and participation in specific projects as an aid to solution of their problems. Recommending the placement of lighting study projects in present committees or the appointment of study project committees to the Society President and to expedite such study projects and guide accepted reports into proper Government channels.

G. D. Mills, Co-Chairman, Department of National Defense, New Army Bldg., Ottawa, Ont.
A. F. Wakefield, Co-Chairman, The F. W. Wakefield Brass Co., Vermilion, Ohio

J. W. Bateman	J. F. Morton
H. R. Blackwell	K. M. Reid
O. P. Cleaver	John S. Walsh
C. L. Crouch	M. N. Waterman

HISTORICAL — To assemble and make available for current reference and to prepare in suitable and durable form for posterity, such historical facts, printed memorabilia, photographs, voice records, museum specimens and allied items as may be judged worthy of composing a continuing digest of the record of the Society's history.

S. G. Hibben, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

R. B. Burton, Sr.	Charles Franck
Julius Daniels	C. A. B. Halvorsen
Leo Dolkart	J. L. Stair

G. H. Stickney

LIGHTING SERVICE — To stimulate and promote the discussion and practical application of lighting recommendations and to conduct a Lighting Service Forum in connection with the National Technical Conference.

L. E. Tayler, Chairman, Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

Paul H. Hildebrand	David D. Lees

Robert Taylor

MEMBERSHIP — To develop plans and supervise the operation of the individual membership activity of the Society.

T. W. Lauer, Chairman, Rumsey Electric Co., 1007 Arch St., Philadelphia, Pa.

Section and Chapter Representatives

John Adams	Earl Lyle
William Addison	Howard Long
Clark Baker, Jr.	Gene McArdle
Douglas H. Baker	A. McDowell
Nick Ball	V. O. McCluskey
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Leland M. Latimer	John Thompson
Samuel La Cornu	George W. Thunen
P. J. Lepore	Milton Uhr
Harold G. Linder	O. S. Wilkins

J. M. Witbeck

NATIONAL TECHNICAL CONFERENCE — To be completely responsible, subject to the approval of Council, for the general coordination of all conference activities, for selecting and recommending time and place for review of the plans and budgets of the National Technical Conference Executive Committee and in cooperation with the Papers Committee for the satisfactory time allocation for the Technical Papers sessions; according to Procedures and Policies as adopted by Council.

C. N. Laupp, Chairman, Wisconsin Electric Power Co., 231 W. Michigan St., Milwaukee, Wis.

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C. J. Berry	L. E. Tayler
W. W. Booth	A. S. Turner
G. F. Dean	L. C. Twichell
J. C. Forbes	M. N. Waterman
R. F. Hartenstein	R. M. Zabel

Conference Executive Committee

A. S. Turner, Chairman, General Electric Co., 1405 Locust St., Philadelphia, Pa.

R. M. Hoot, Vice-Chairman, Philadelphia Electric Company, 1000 Chestnut St., Philadelphia, Pa.

J. J. Tynan, Secretary, Atlantic City Electric Co., P. O. Box 567, Atlantic City, N. J.

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C. J. Berry	K. T. Goodall
F. L. Calvi	T. W. Lauer
Maxwell Cole	D. D. Lees
H. A. Crossdale	H. J. Martin
Iver Dixon	C. C. Shotwell

PROCEDURES AND POLICIES — To study problems of Society procedure and policy referred to the Committee by Council, and to formulate recommendations to Council for the statement, revision, or clarification of these procedures and policies consistent with the Constitution and Bylaws of the Society.

E. M. Strong, Chairman, Cornell University, Ithaca, N. Y.

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J. S. Schuchert	Walter Sturrock
C. C. Shotwell	J. F. Whitehead, Jr.

F. C. Winkler

PUBLIC RELATIONS AND INFORMATION — To prepare and disseminate information about the activities, accomplishments, programs, objectives and policies of the Society and about the place of illuminating engineering in modern society; to formulate and submit public relations policies and plans for the Society.

J. F. Whitehead, Jr., Chairman, Day-Brite Lighting Corp., 5411 Bulwer Ave., St. Louis, Mo.

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H. G. Hrivnatz	G. Watters
John K. Hughes	G. H. Wheatley
James Hull	Richard E. White

REGIONAL ACTIVITIES — To represent the respective Regions before the Council and to keep the Council informed regarding the affairs of the Regions. To stimulate Society activities, to encourage joint meetings of Sections and Chapters including Regional Conferences within the respective Regions and to promote the expansion of the Society.

R. F. Hartenstein, Chairman, Ohio Edison Co., Akron, Ohio.

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G. B. Buck, II	Glenn E. Park
M. B. Hastings	C. B. Pederson
L. A. Hobbs	G. J. Taylor
W. J. Lind	L. C. Twichell

RESIDENCE LIGHTING FORUMS — To stimulate and assist the Residence Lighting Forums of the Society and to encourage the formation of additional Forums. To conduct a Residence Lighting Forum in connection with the National Technical Conference.

Katharine T. Goodall, Chairman, Philadelphia Electric Co., 900 Sansom St., Philadelphia, Pa.

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Mary Dodds	Winonah Murphy
Lillian Eddy	Jan Reynolds
Myrtle Fahsbender	Frances E. Rosier
May Love Gale	Kerr Sanders, Jr.

Mary Taepke

SUSTAINING MEMBERSHIP — To develop plans and supervise the operation of the Sustaining Membership activity in the Society according to the Procedures and Policies adopted by Council.

C. C. Shotwell, Chairman, Philadelphia Electric Co., 1000 Chestnut St., Philadelphia, Pa.
E. H. Church, Vice-Chairman, Benjamin Electric Mfg. Co., Des Plaines, Ill.

G. F. Dean	Charles R. Long
Leon T. Johnson	W. C. Mutchler

R. C. Paslay

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D. Michelson	L. T. Wilcox
Robert M. Miller	H. L. Williamson
Frank Moos	E. Burton Wolf

TASK COMMITTEES

LIGHTS DIAMOND JUBILEE—1954

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C. M. Cutler	C. C. Shotwell
R. F. Hartenstein	R. G. Slauer

J. S. Walsh

TRUSTEES, I.E.S. HEADQUARTERS RETIREMENT PENSION PLAN

S. G. Hibben, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

W. W. Booth	K. M. Reid

E. M. Strong

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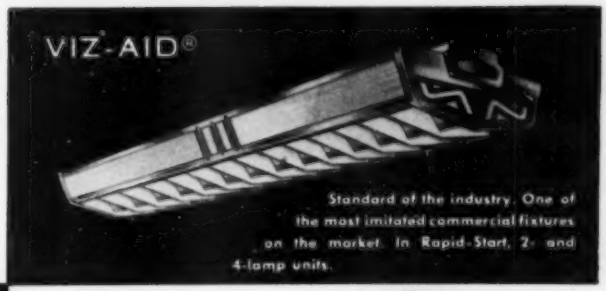
LOOK AT DAY-BRITE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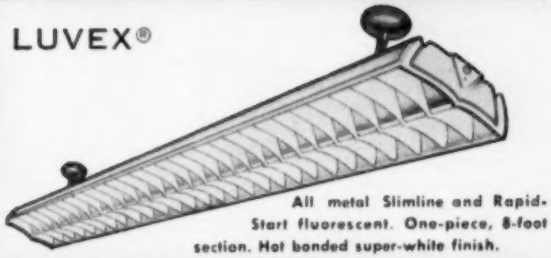

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I.E.S. - U. S. PUBLIC HEALTH SERVICE — To outline a method of making a survey of the visual factors of the working environment and the workers' vision and evaluating the findings in terms of visual comfort and effectiveness and eye health.

J. F. Parsons, Chairman, Niagara Mohawk Power Corp., Buffalo, N. Y.

B. S. Benson	George Clayton
Mrs. Tula Brocard	Neal Jacobus
L. J. Cahill	A. L. Koven

R. P. Teele

TECHNICAL COMMITTEES

AVIATION LIGHTING — To study the application of light and lighting to the spaces and functions involved in the operation of aircraft.

D. C. Miller, Chairman, General Electric Co., Nela Park, Cleveland, Ohio.

H. J. C. Pearson, Vice-Chairman, Civil Aeronautics Administration, Technical Development Division, Indianapolis, Ind.

P. H. Greenlee, Secretary, Grimes Mfg. Co., Urbana, Ohio.

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F. C. Ashe	A. L. Lewis
J. P. Bartow	R. E. Madigan
H. R. Blackwell	N. H. McIntyre
R. C. Blatt	W. E. K. Middleton
F. B. Brady	L. B. Moore
F. C. Breckenridge	W. A. Pennow
A. H. Clarke	T. H. Projector
H. A. Cramer	V. J. Roper
R. E. Dahlin	L. C. Simpson
I. F. Fagin	R. J. Stefany
W. C. Fisher	L. C. Vipond
J. P. Hoxie	Martin Warskow

A. B. Winters

CIVIL DEFENSE, LIGHTING FOR — To appraise and report on special lighting problems connected with emergency military operations that directly involve civilian defense and protection, such as equipment for bomb shelters, special street and vehicular lighting, mobile self-contained lighting facilities for use in bombed areas, and emergency lighting devices and visual aids to movement in the event of power failure.

J. W. Bateman, Co-Chairman, Canadian General Electric Co., Ltd., 165 Dufferin St., Toronto, Ont.

J. C. Forbes, Co-Chairman, General Electric Co., 570 Lexington Ave., New York, N. Y.

J. S. Walsh, Secretary, Pacific Gas & Electric Co., 245 Market St., San Francisco, Calif.

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R. B. Brown, Jr.	Kirk M. Reid
K. E. Hollingsworth	L. J. Schrenk
R. M. Hoot	R. G. Scott
W. F. Little	T. H. Shepherd
G. D. Mills	H. E. Stafford

J. S. Walsh

COLOR AND ILLUMINATION — To study, evaluate and report on the effect of color in relation to the art and science of illumination.

J. A. Meacham, Chairman, Sherwin-Williams Co., Midland Bank Bldg., Cleveland, Ohio.

R. C. Allison, Vice-Chairman, T. Eaton Company, 190 Yonge St., Toronto, Ont.

R. L. Biesele, Jr.	R. M. Hanes
A. A. Brainerd	Harry Helson
L. H. Brown	C. F. Jensen
R. A. Boyd	W. H. Kahler
C. L. Cottrell	H. L. Logan
G. F. Dean	Gladys Miller
R. M. Evans	Dorothy Nickerson
Dean Farnsworth	W. D. Riddle
C. E. Foss	Francis Scofield
W. C. Granville	D. E. Spencer
S. K. Guth	G. F. Wakefield

DAYLIGHTING — To study the problems involved in daylighting, develop recommended practices and report thereon.

R. A. Miller, Chairman, Pittsburgh Plate Glass Co., 420 Fort Duquesne Blvd., Pittsburgh, Pa.

H. B. Vincent, Vice-Chairman, Owens-Illinois Glass Co., 1700 N. Westwood Ave., Toledo, Ohio.

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G. F. Bauer	W. F. Little
R. L. Biesele, Jr.	H. E. Machamer
F. W. Bishop	R. W. McKinley
R. A. Boyd	J. A. Meacham
H. S. Bull	E. C. Miles
W. W. Caudill	D. R. Muir
E. W. Conover	S. W. Quisenberry
Doyt Early	W. C. Randall
W. B. Ewing	F. K. Sampson
W. E. Folsom	D. E. Spencer
B. F. Greene	G. W. Thomas
C. D. Gibson	E. E. Vesey
J. W. Griffith	Andrew Vogel
H. S. Herbert	K. C. Welch
G. N. Hingston	O. P. Wenzler

FARM LIGHTING *(Formerly Farm Buildings and Work Area Lighting)* — To study the application of light and lighting of farm buildings, surrounding work areas and other rural locations and to report thereon.

O. C. Lange, Chairman, Pennsylvania Power & Light Co., 9th and Hamilton Sts., Allentown, Pa.

T. M. Barr	O. D. Hunt
Edith Buchholtz	Arthur Kramer
J. P. Ditchman	Howard Long
P. H. Hildebrand	Joseph Schaenzer

A. J. VonBurg

I.E.S. - A.S.H.V.E. JOINT COMMITTEE — To study the relationship between lighting and various factors that enter into the thermal environment and report thereon.

Walter Sturrock, Chairman, General Electric Co., Nela Park, Cleveland, Ohio.

R. W. McKinley E. H. Salter

A.S.H.V.E. Cooling Load Subcommittee

John Everetts, Jr. A. T. Jorn

J. N. Livermore

ILLUMINATION PERFORMANCE RECOMMENDATIONS — To prepare illumination performance recommendations for luminaires conforming to I.C.I. classifications, excluding residential.

B. S. Benson, Jr., Chairman, Benjamin Electric Mfg. Co., Des Plaines, Ill.

Kurt Franck	J. F. Parsons
Leslie Innis	R. P. Teele
W. H. Kahler	G. P. Wakefield
W. F. Little	William Weibel

INDUSTRIAL LIGHTING — To initiate, follow up and coordinate lighting study projects in the industrial field, review the reports of the various subcommittees in this field and make recommendations to Council.

J. R. Chambers, Chairman, Benjamin Electric Mfg. Co., Des Plaines, Ill.

A. A. Brainerd	C. C. Keller
C. E. Egeler	W. H. Kahler
C. D. Hollister	Howard Long

W. P. Lowell, Jr.

Lighting in the Canning Industry

Carl O. Martin, Chairman, Benjamin Electric Mfg. Co., 829 Folsom St., San Francisco, Calif.

L. H. Brown	Robert S. Prussia
S. H. Hazelton, Jr.	Robert Thallon
K. M. Noble	D. C. White

H. K. Wilder

Lighting of Central Station Properties

L. G. Parks, Chairman, Ebasco Services Inc., 2 Rector St., New York, N. Y.

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R. S. Bucher	R. M. Graves
H. F. Carroll	Carter Lewis
H. A. Cook	W. S. Mowry
R. W. Corwin	D. J. O'Neill
H. E. D'Andrade	C. B. Stephens
V. L. Dzwonczyk	D. W. Taylor

Lighting in the Clothing Industry

Norman Kridel, Chairman, Rochester Gas and Electric Co., 89 East Ave., Rochester, N. Y.

B. A. Thomas L. C. Twichell

Carl Uthe

Lighting for Graphic Arts — Printing Industry

Ralph Enghouser, Chairman, Sylvania Electric Products, Inc., 1938 Lincoln Liberty Bldg., Philadelphia, Pa.

Michael Flynn	Percy Holmes
William Harrison	John Mucha

J. Wallace Scott

Lighting in Laundries

O. A. Hill, Jr., Chairman, Public Service Co. of Northern Illinois.

G. F. Allen	Carl F. Jensen
J. R. Chambers	R. R. Lusk
A. L. Christensen	W. S. E. Miller
R. R. Hill	A. A. Sobolik

Mine Lighting

C. M. Crysler, Chairman, General Electric Co., 238 W. Carson St., Pittsburgh, Pa.

Lighting in Petroleum Industry

Dale H. Watt, Chairman, Watt Plumbing, Air-conditioning & Electric Co., Tulsa, Okla.

H. D. Hughes	P. R. Sheline
F. F. House	T. C. Wier

Lighting in Sheet Metal, Stamping, Folding and Shearing Industry

Floyd W. Sell, Chairman, Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

H. A. Bolts	J. M. Marlin
E. L. Frase	T. H. Roughley

Lighting in Saw Mills

James Barnes, Chairman, Pacific Gas and Electric Co., San Rafael, Calif.

D. M. Finch	John Keyes
Emanuel Fritz	Norman Schiewe
Jerry Howard	P. S. Schmidt

K. B. Stoddard

Lighting in the Textile Industry
(Joint Committee with A.S.M.E.)

W. L. Kelley, Jr., Chairman, N. E. Machine & Electric Co., 77 Bayley St., Pawtucket, R. I.

INSTITUTIONAL — To initiate, follow up and coordinate lighting study projects in the field of public buildings and private institutions, review the reports of the various study subcommittees in this field and make recommendations to Council.

James H. McCulloch, Chairman, General Electric Co., 1635 Broadway, Fort Wayne, Ind.

George Smedberg	William H. Smith

Carl Zersen

Lighting in Hospitals — William H. Smith, Chairman, 20 South Senate, Indianapolis, Ind.
Lighting in Hotels — C. I. Sayles, Chairman, Cornell University, School of Hotel Administration, Ithaca, N. Y.

Lighting in Kitchens — Carl Zersen, Chairman, Chicago Lighting Institute, 37 So. Wabash Ave., Chicago, Ill.

Lighting in Theaters—George Smedberg, Chairman, Associated Lighting Service, 488 Bryant Avenue, San Francisco, Calif.

LIGHT CONTROL AND EQUIPMENT DESIGN— Collect and correlate the knowledge and data on means and methods of controlling, directing, reflecting, transmitting and diffusing light and on the principles and practices of equipment design.

D. L. Williams, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

G. R. Baumgartner	M. P. Morse
B. S. Benson, Jr.	F. M. Neal
R. D. Bradley	C. N. Sprankle
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LIGHT SOURCES — To correlate and report available information as to the physics of light and light production and the characteristics of current light sources.

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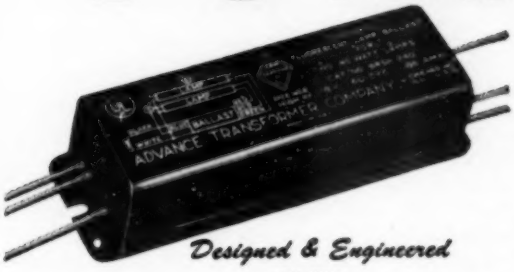

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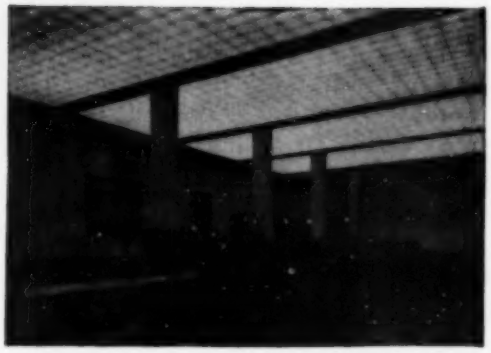
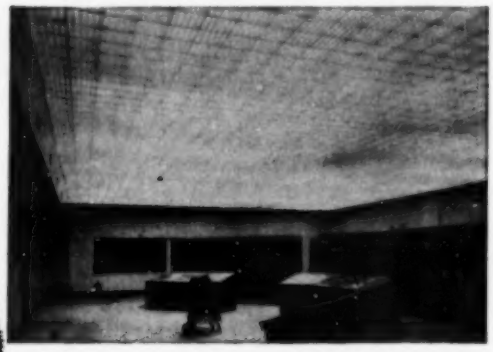


● Illustration shows a modern bank installation, where "Luve-Tile" helped to achieve an air of efficiency.



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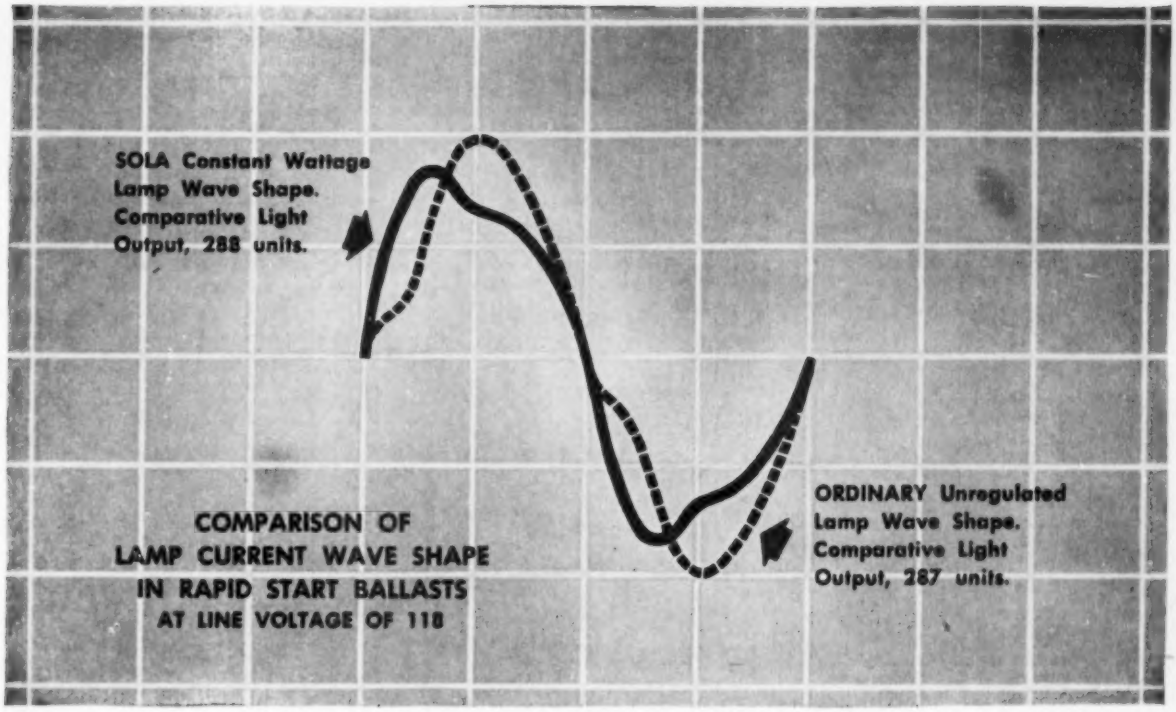

Low peak/rms ratio of Sola Rapid-Start Constant Wattage Ballasts extends lamp life

The life of rapid-start fluorescent lamps is inversely proportional to the peak/rms ratio of the lamp's current wave shape. The patented Sola constant-wattage, rapid-start circuit results in a ballast with an extremely low ratio — for example, approximately 1.5 at 118 volts—along with excellent wave shape.

This ballast regulates lumen output within ±2% regardless of line variations from 106 to 130 volts.

Its 300v open circuit voltage, from the lamp to the starting aid, results in positive starting.

A Sola sales engineer will be happy to give you all the illuminating facts.

COMPARISON OF PEAK/RMS CURRENT RATIO, IN RAPID START LAMPS OPERATING FROM SOLA CONSTANT WATTAGE BALLAST AND ORDINARY UNREGULATED BALLAST

LINE VOLTAGE	PEAK/RMS RATIO		SOLA SUPERIORITY
	SOLA	ORDINARY	
106	1.308	1.535	42.4%
118	1.472	1.567	16.7%
130	1.552	1.651	15.2%

Reduces relamping . . . keeps lumen output constant

SOLA *Constant Wattage* **BALLASTS**

WRITE FOR BULLETIN 3D-FL-191

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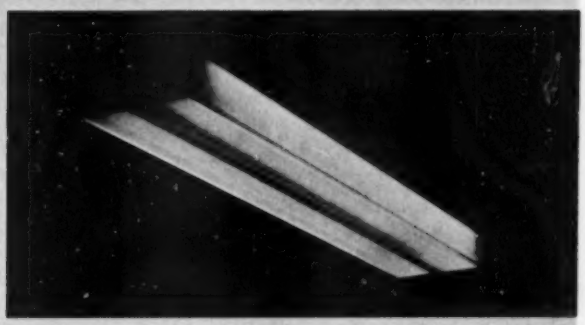
stripped down to bare luminosity There are no retaining structural members to garble the luminosity of Globe's revolutionary new "Challenger"—an all-plastic luminaire with an overall depth under four inches.

Side panels and bottom are connected by an interlocking system of construction, engineered to prevent bowing or distortion.

The clear plastic, prismatic lens bottom directs light intensity in a straight downward path, tapering sharply at oblique angles. Extruded polystyrene, beaded-edge side panels provide controlled diffusion.



Maintenance is a snap. A slight upward pressure easily disengages the light weight lens bottom. Dust infiltration is reduced to a minimum.

"Challenger" promises to outmode any luminaire of its type. It is one of various lighting advances presented for the first time in Globe's new 1954 catalog. Write for your copy. **Globe Lighting Products Inc.** 2121 South Main Street, Los Angeles 7, California.

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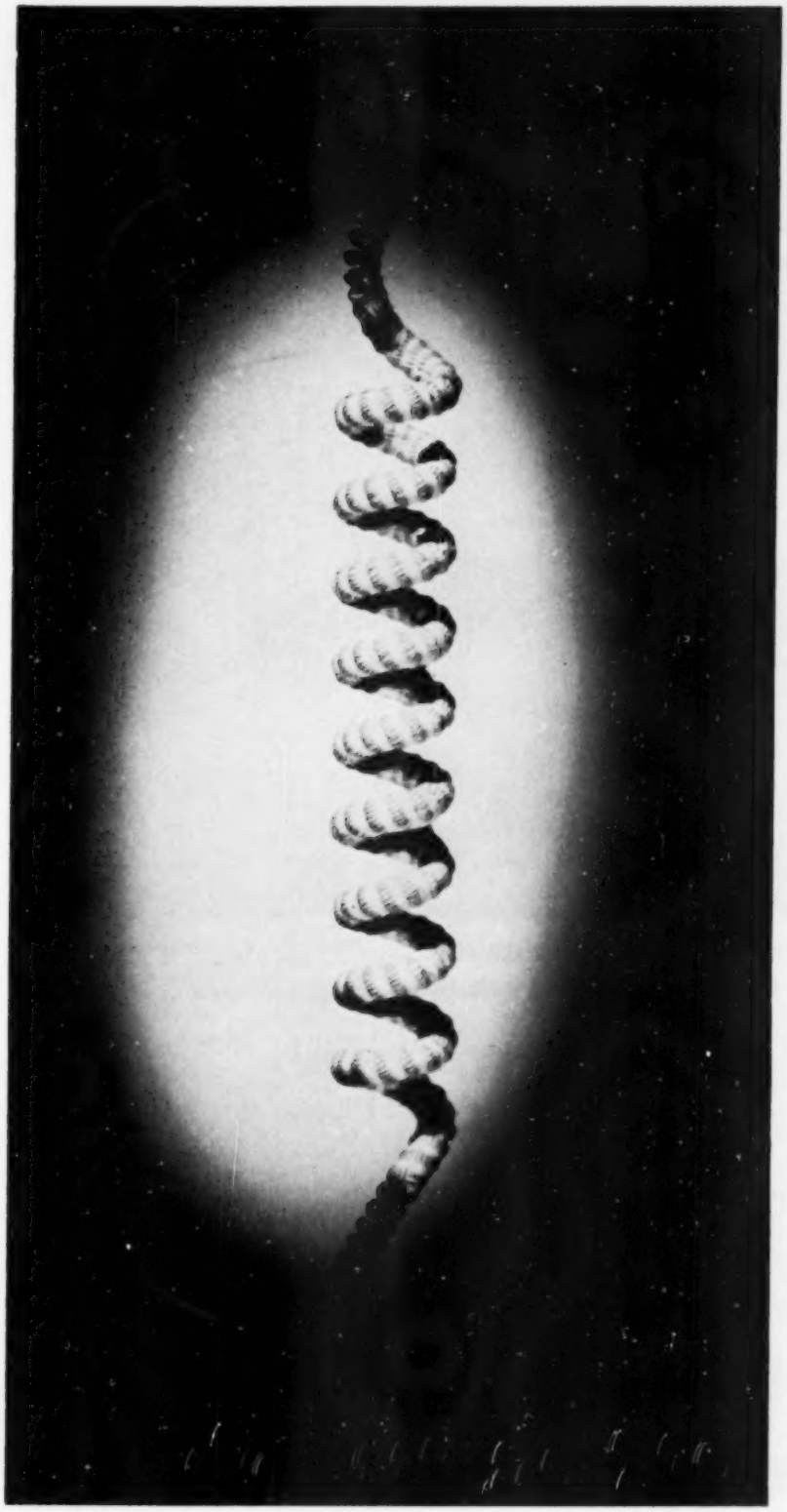

New twist on old idea makes G-E fluorescent lamps last longer

ONE of the most important materials in a fluorescent lamp is the little bit of chemical at each end of the tube. The current flows through it, electrons flow out, and the lamp starts to glow.

The old idea was to hold the chemical on a double-twisted wire coil. General Electric's new idea was to go that one better: give the wire a *triple* twist. This not only holds more chemical, it also holds it longer.

The result of course is longer lamp life and more light for your money.

General Electric's triple coil is used in G-E slimline and other G-E instant-start lamps. Just one more example of why...

You can expect the best value from General Electric fluorescent lamps

You can put your confidence in—

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(Continued from page 38A)

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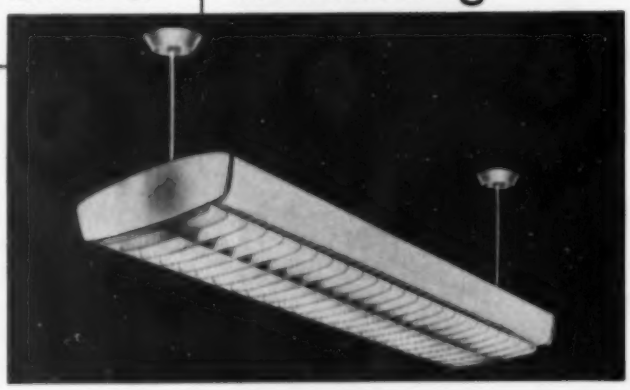

The Arthur

A & B 14000 SERIES

4 & 8 FOOT FLUORESCENT LUMINAIRES

Using standard or slimline lamps

A VERSATILE DIRECT-INDIRECT LUMINAIRE FOR INDIVIDUAL OR END-TO-END PENDANT MOUNTING

The 2-lamp Arthur, with its direct-indirect component is designed specifically for pendant mounting. Sloping ends, plus trim, shallow lines and all white finish give the unit a particularly light and graceful appearance.

Diffusing polystyrene side panels and 35° x 35° louver shielding result in an eye-comforting brightness pattern. When lighted, the Arthur blends harmoniously into the ceiling.

Open chassis construction makes the unit easy to install; all metal parts are die formed; 8-foot units require hangers only on the ends. Side panels slip into position; hinged louver opens or removes quickly. Unit is wired complete, ready to install, less lamps.

WRITE FOR BULLETIN NA *It details complete specifications and engineering data for the Arthur.*

PITTSBURGH REFLECTOR COMPANY

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Lighting

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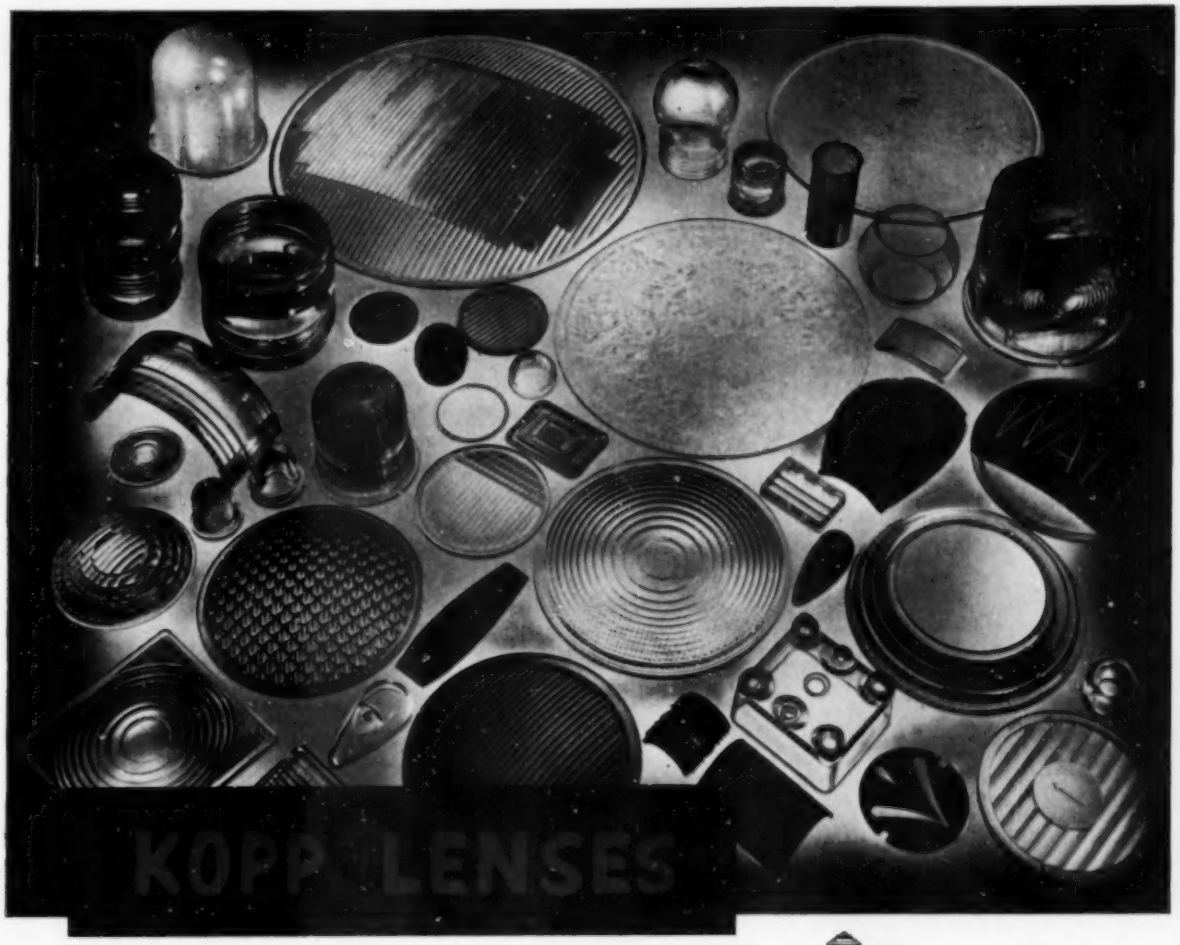
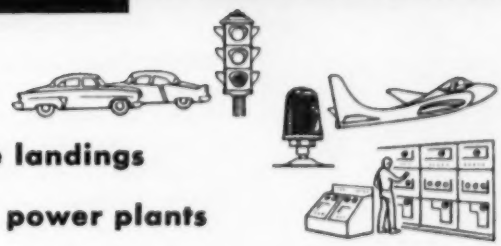


———— say "go" to traffic

———— guide aircraft to safe landings

———— signal "all's well" in power plants



Vital services are performed by Kopp lenses and other glass products. Many of these applications call for accurate control of a beam of light—which may be concentrated, spread or diffused. Uniform transmission of colors may be required; resistance to heat and thermal shock are often needed.

Kopp specializes in the production of glass parts requiring skillful engineering design and careful, accurate workmanship. We will be glad to submit ideas, designs and prices for your consideration.

WRITE FOR
the new brochure describing the design and manufacture of Kopp Glass Products.

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Building—*Through Business —for a Better America!*

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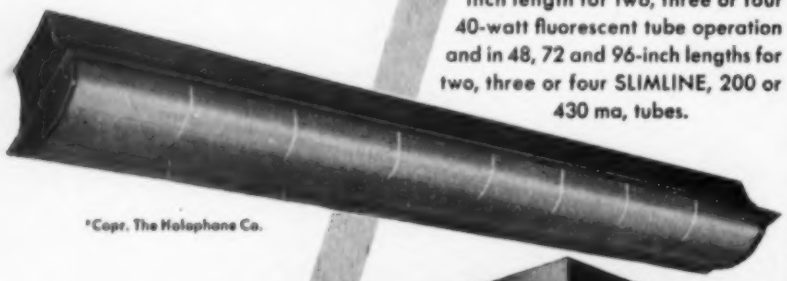
LEADS IN EFFICIENCY...BEAUTY

THL SERIES

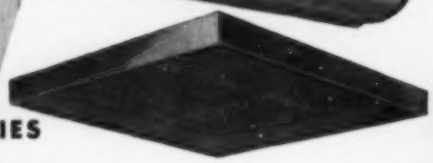
RECESSED TROFFERS WITH CURVED HOLOPHANE* CONTROLENS

Engineered to provide a well controlled distribution of light without ceiling contrast. May be had with lay-in or hinged Controlens...in 12" or 13¾" width... 7⅛" or 6" depth. Available in 48-inch length for two, three or four 40-watt fluorescent tube operation and in 48, 72 and 96-inch lengths for two, three or four SLIMLINE, 200 or 430 ma, tubes.



*Copr. The Holophane Co.

SWTL SQUARE SERIES



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INVESTIGATE the entire line of *LEADLIGHT* Fluorescent Lighting Fixtures. Write for new Catalog today.

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Desires connection with Utility; fifteen years broad experience all phases Utility Lighting Operations. Well schooled in over-all company relations. A-1 References. Address Box 200, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N.Y.

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Excellent opportunity for man who is qualified as a Lighting Engineer. Also, must have selling experience to wholesale a fine Lighting Line for the (Washington, D.C.) (Atlanta, Georgia) area; for national concern, manufacturers of Engineered Lighting Fixtures. (Slimline and Fluorescent). Address Box 206, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N.Y.

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To work in engineering division of architectural firm. Lighting, wiring, power distribution. Large volume of school work. Write details of training, experience and salary desired to Wolf & Hahn, R.A., 459 Hamilton Street, Allentown, Pennsylvania.

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We now represent two of the nation's top manufacturers of lighting fixtures—the largest manufacturer of commercial adjustable accent lighting — as well as the country's largest manufacturer of residential lighting fixtures. We do a volume in the millions.

We have four salesmen calling on architects, engineers, chains and utilities in conjunction with the electrical wholesalers' salesmen. Two of our men are qualified lighting engineers (I.E.S. members).

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• Cooler, cleaner lighting, plus longer lamp life. That's what you can expect with the new ABOLITE "All-White" lifetime, porcelain enameled fixtures. The ventilating slots provide automatic air circulation, prevent dust from fogging lamp and reflector.

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Needed by the country's most progressive manufacturer of lighting equipment, who specialize in fine ornamental as well as engineered lighting fixtures.

An excellent salary commensurate with ability if you have imagination, a knowledge of period styles as well as modern lighting ideas.

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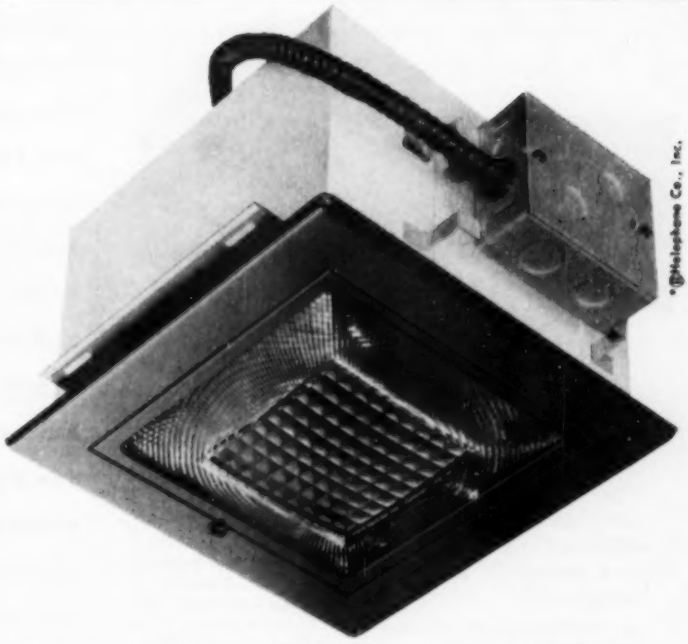
DRAMATIZE

YOUR LIGHTING



*Telephone Co., Inc.

Add dramatic effectiveness in lighting of restaurants, stores, lobbies, private offices, reception and display areas with Sunbeam's new, "dropped lens" incandescent recessed fixtures. Attractive prismatic Controlenses* with curved sides bend light into useful zones eliminating glare from normal viewing angles and reducing ceiling contrasts. These smart units are available in shallow or deep; narrow or wide dimensions.

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We design and fabricate ornamental lighting fixtures and lanterns of genuine bronze and wrought iron, for churches, schools, banks and public buildings, to your order or to your architect's specifications. No order is too large, none too small, to receive our personal attention.

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KESCO
Non-ferrous
SHALLOW DEPTH
CANOPY FIXTURE

KESCO recessed canopy fixtures are ideal for installation in poured concrete exterior canopies, where rugged construction, shallow depth, and durable finish and materials are requirements.

- 4½" Depth
- 10¼" Square
- 7/32" Wall Thickness
- Cast Aluminum Box
- Separately Detachable Two-Piece Satin Finish Cast Aluminum or Bronze Frame
- Drop Hinge Assembly for Easy Bulb Replacement and Cleaning
- Approved for One 150-Watt Incandescent Lamp
- Flat or Drop-lens Type

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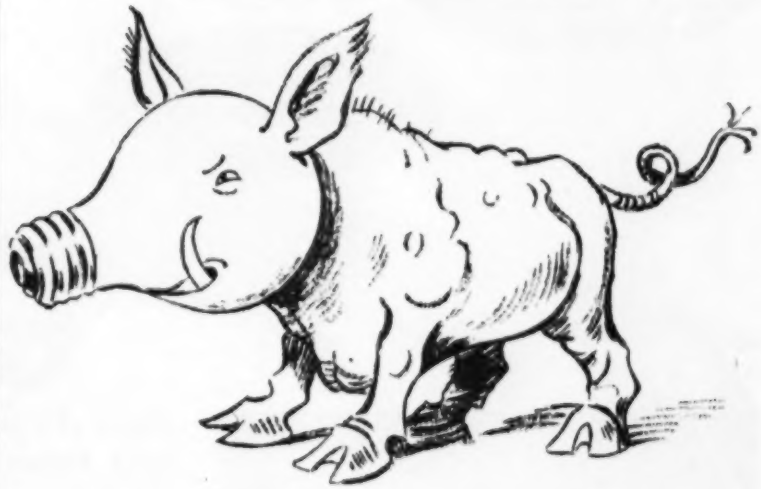
"WHAT'S BEHIND IT?" THAT'S *the true measure of lighting fixture value. Behind the Quality and Continuous Dependability of Miller Fluorescent, Incandescent, Mercury fixtures for industry, commerce and schools—are 110 years manufacturing know-how—1,000 combined man years field lighting engineering—million-dollar production facilities.*

Meriden, Conn. Leaders in lighting since 1844

WATCH OUT for the WATT-HOG



Does this *Watt-hog* with his dim and dirty face root you out of good light and decent maintenance economy? Not if you follow the suggestions in the *Champion Maintenance Manual** and make a practice of buying the right lamps —efficient, long-lasting *Champion Lamps.*

**CHAMPION LAMP WORKS*

**Your name and company address on a postcard will bring you a free copy by return mail.*

CHAMPION LAMP WORKS

588 Broad Street, Lynn, Massachusetts

CHAMPION

ultra-shallow fluorescent luminaires from MITCHELL

maximum lighting efficiency

minimum maintenance

ultra-modern styling

MITCHELL THINLINE

Choice of 4 and 8 foot lengths in 2 and 4 lamp models — All lamp types available

New "Thinline" answers the need for high-efficiency illumination, coupled with attractive styling. Outstanding advantages include: ultra-shallow contour provides pleasing, streamlined installation; special translucent "Evenglo" plastic sides and louver give higher light transmission, yet provide tremendous hiding power and diffusion for desirable low surface brightness; superior louver design with proper 45°/45° cutoff conceals lamps from all normal viewing angles. Advance styling, unusually low maintenance factor and high lighting efficiency make the new MITCHELL "Thinline" Luminaires outstanding values in commercial fluorescent lighting.

MITCHELL POLARIS

The new ultra-shallow "Polaris" luminaire incorporates all the fine features described at right, with Penticore prismatic glass shielding delivering a light transmission factor of 85%, with excellent diffusing quality. The combination of high light output and the low surface brightness of the "Evenglo" sides and Penticore Glass shield creates ideal, harmonious lighting for the finest commercial interiors.

MITCHELL MODERNIZER

This is the new ultra-shallow luminaire designed to meet the requirements of large commercial installations where high-efficiency lighting and exceptional low cost are primary considerations. The luminaire features a V-spine design which provides a highly reflective surface to increase down-light intensity. The 8-foot units feature special "tandem" design (two 4-foot units with one 8-foot body channel) to save installation time and assure perfect alignment in continuous rows.

Note the ultra-shallow contour. When flush-mounted, the luminaire presents a beautiful streamlined appearance.

Concealed combination hinge and latch on each side of luminaire permit easy removal of louver from either side.

New Rapid-Start units are available; they slash maintenance cost by eliminating expense of replacing starters.

"Evenglo" translucent extruded Polystyrene side panels provide desirable uniform low surface brightness.

Write for complete descriptive brochures describing the new MITCHELL Ultra-Shallow "Thinline," "Polaris" and "Modernizer" Luminaires

where quality counts — SPECIFY MITCHELL

MITCHELL MANUFACTURING CO.

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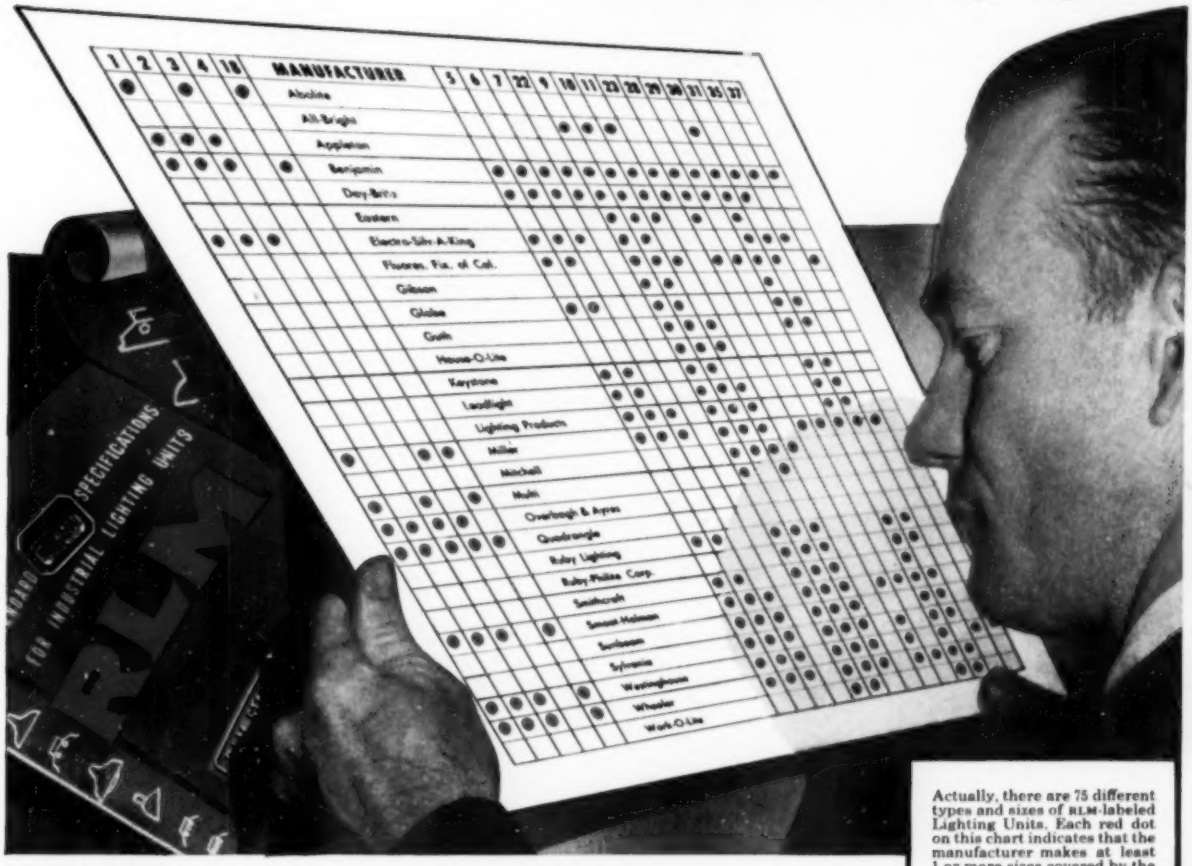
Here are your answers to 2 IMPORTANT QUESTIONS about Industrial Lighting Units



Actually, there are 75 different types and sizes of RLM-labeled Lighting Units. Each red dot on this chart indicates that the manufacturer makes at least 1 or more sizes covered by the particular RLM Specification.

Key to Spec. Nos.:

INCANDESCENT UNITS:

1. Dome (100-1000w)
2. Deep Bowl (100-1000w)
3. Sym. Angle (100-1000w)
4. High Bay (500, 1000w) Porcelain Enameled
18. Glassteel Diffuser (200-1000w)
40. High Bay Aluminum (500, 1000w)

FLUORESCENT UNITS:

Closed-End Reflectors:

5. 2-40w lamps, 48"
6. 3-40w lamps, 48"
7. 2-85w lamps, 60"
22. 2-40w w/shield, 48"

Open-End Reflectors:

9. 2-40w lamps, 48"
10. 3-40w lamps, 48"
11. 2-85w lamps, 60"
23. 2-40w w/shield, 48"
28. 2-58w, 72"
29. 3-58w, 72"
30. 2-75w, 96"
31. 3-75w, 96"

Semi-Direct Units:

35. 2-40w, 48"
36. 2-58w, 72"
37. 2-75w, 96"

Chart as of Jan. 1, 1954

1 WHY are RLM Specifications Important to me?

ANSWER: RLM Specifications furnish you with basic, nationally-accepted minimum standards of efficiency, design, performance and quality in industrial lighting equipment. This latest-edition 52-page RLM Specifications Book puts all 21 RLM Specifications at your fingertips, complete with coefficient of utilization tables and candlepower distribution curves. In addition, there are four pages of reasons why RLM Specifications are important to everyone who buys, sells or specifies industrial lighting equipment. Send for your COMPLIMENTARY COPY of the RLM Specifications Book ... there is no obligation!

2 WHO makes RLM-Labeled Units I want to Specify?

ANSWER: As shown by this chart, which is also included with the RLM Specifications Book, there are 29 different manufacturers who make RLM-labeled lighting equipment. Each RLM Unit must conform to the minimum performance and quality standards required by RLM Specifications. However, every manufacturer is free to incorporate his own special features, construction refinements and operating advancements — such as sockets, control equipment, wiring, etc. Send for your FREE RLM Book for more details. RLM Standards Institute, Suite 823, 326 West Madison Street, Chicago 6, Illinois.

RLM STANDARDS INSTITUTE
INCORPORATED

The letters RLM stand for Reflector and Lighting Equipment Manufacturers

MANUFACTURER'S NAME
COMPLIANCE WITH
RLM
ELECTRICAL TESTING LABORATORIES, INC.

R508

work-inspiring lighting created by GUTH* GRATELITE CEILINGS

Guth

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Work is a pleasure with this velvetized light . . . diffused by beautiful, lattice-like GRATELITE, installed in the offices of MacKenzie, Knuth & Klein, Architects of Flint, Michigan.

data:

Room Size: 23'4" x 9'10" x 10'9"

Luminaires: Guth Super-Strips
12 96" T-12 Lamps, 4500° White
Mounted on 24" Centers, 10'6" high

GRATELITE Ceiling: Mounted 8'6" above floor

Foot-Candles: All Super-Strips on—86 F. C.
One-Half Super-Strips on—42 F. C.

BRIGHTNESS READINGS:	FOOT LAMBERTS	C.P./SQ. IN.
1. *GRATELITE Ceiling at approx. 30° Angle*	120	.260
2. *East Wall (French Gray)*	20	.046
Dado	13	.028
3. *South Wall (Deep Coral)*	9½	.021
4. *Floor (Natural Cork Tile)*	17½	.038
5. *Desk (Chartreuse)*	36	.080

Just think: 86 Foot-Candles—and yet only 120 Foot Lambert Brightness! Never before was such low brightness with such high illumination values thought possible. Make this dream come true for you. Write on your letterhead for Catalog 905-I and GrateLite layout guide.

THE EDWIN F. GUTH COMPANY ST. LOUIS 3, MO.

Leaders in Lighting since 1902